U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-275 332

Construction Inspection Guide. Volume 3

Environmental Protection Agency, Washington, D C

1976

PB 275 332

EPA-430/9-76-005-c

CONSTRUCTION INSPECTION GUIDE

VOLUME 3

1976

Municipal Construction Division
Office of Water Program Operations
U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-430/9-76-005 -c	2.	3. RECIPIENT'S ACCESSION NO. PB275332
4. TITLE AND SUBTITLE Construction Inspection Guide Volume III		5. REPORT DATE 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO. MCD-23
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Water Program Operations Municipal Construction Division Washington, DC 20460		10. PROGRAM ELEMENT NO. 2 BG 647 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS US EPA, Office of Water Program Operations 401 M Street, SW Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA/700/02

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This guide was issued by the U.S. Environmental Protection Agency for the use of personnel who inspect the day-to-day construction of municipal wastewater treatment facilities. It is intended to assist construction inspectors in examining the detailed construction of the structural, mechanical, and electrical features of a modern facility.

Volume III covers the following topics: heating; ventilating, air supply and distribution systems; refrigeration and air conditioning; interior electrical; exterior electrical; cathodic protection; installation of equipment; pile construction; levee construction and earth embankment construction; and drilling for subsurface investigations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water Pollution Control	Construction Inspection Construction Inspection	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES 270
	20. SECURITY CLASS *(This page)*	22. PRICE A12 - A01

EPA Form 2220-1 (9-73)

FOREWORD

The Federal Water Pollution Control Act Amendments of 1972 set in motion a comprehensive program to clean up the Nation's waters. Recognizing that many local governments could not afford to build needed treatment facilities without financial assistance, Congress dramatically increased Federal aid to help local governments meet the requirements of the Act. The 1972 Amendments made available $18 billion in Federal grants to local governments for wastewater treatment works. The program is administered by the U.S. Environmental Protection Agency in cooperation with the water pollution control agencies of the various States.

This Construction Inspection Guide is being issued to aid the engineers and technicans who inspect the actual construction of a wastewater treatment facility. It should serve as a guide in examining the detailed construction of the structural, mechanical, and electrical features of a modern facility. It cannot, however, replace plans, specifications, experience, and most importantly, engineering judgement. Whenever a difference exists between the guide and contract documents, or Federal, State and Local requirements, the contract documents or governmental requirements take precedent.

Comments, recommendations, or suggestions for modification or insertion of additional material are solicited. They should be sent to: Director, Municipal Construction Division, U.S. Environmental Protection Agency, 401 "M" Street S.W., Washington, D.C. 20460.

The Environmental Protection Agency extends acknowledgement to the U.S. Army Corps of Engineers, who originally published this guide, and the Naval Facilities Engineering Command, who provided the negatives, for their joint permission to reprint this guide with minor editorial changes.

John T Rhett

John T. Rhett
Deputy Assistant Administrator
for Water Program Operations

INSTRUCTIONS FOR OBTAINING ADDITIONAL COPIES OF THIS GUIDE

This guide is available, free of charge, for personnel who inspect the day-to-day construction of municipal wastewater treatment facilities funded in part, by grants from the U.S. Environmental Protection Agency.

To order the "Construction Inspection Guide" write to:

General Services Administration (8-FFS)
Centralized Mailing List Services
Building 41, Denver Federal Center
Denver, Colorado 80225

Please include the following information:

1. Title of publication--Construction Inspection Guide
2. Publication Number--MCD-23
3. Name and location of project where this guide will be used.
4. USEPA Grant Identification Number for this project.

Volume I

Construction Inspection Guide

Table of Contents

Chapter

100 General Information
101 Layout & Quantity Surveys
102 Clearing and Grubbing
103 Earthwork
104 Underground Pipe Systems
105 Paving
106 Grassing, Planting and Erosion Control
201 Concrete for Structures

Volume 2

Construction Inspection Guide

Table of Contents

Chapter

202 Structural Steel

203 Welding

204 Masonry

205 Carpentry

206 Precast & Cast-in-Place Roof Decking

207 Roofing

208 Sheet Metal

209 Furring (Metal), Lathing & Plaster

210 Resilient-Type Floors

211 Dampproofing & Waterproofing

212	Corrugated Roofing & Siding
213	Metal Doors, Door Frames & Windows
214	Cabinets, Casework & Wardrobes
215	Calking, Glass & Glazing
216	Terrazzo: Ceramic & Quarry Tile
217	Movable Accordion & Toilet Partitions
218	Hardware
219	Painting
301	Plumbing & Sprinkle Systems

Volume 3

Construction Inspection Guide

Table of Contents

Chapter

302 Heating
303 Ventilating, Air Supply & Distribution Sys
304 Refrigeration & Air Conditioning
305 Interior Electrical
306 Exterior Electrical
307 Cathodic Protection
308 Installation of Equipment
401 Pile Construction
402 Levee Construction & Earth Embankment Construction
404 Drilling for Subsurface Investigations

CHAPTER 302
HEATING

Para.	Title	Page
302-01	GENERAL	302-1
302-02	MATERIALS AND EQUIPMENT	302-1
	a. General	302-1
	b. Boilers, Furnaces, and Accessory Equipment	302-3
	c. Fuel Burning Equipment	302-5
	d. Draft Fans	302-6
	e. Oil Storage Tank	302-7
	f. Circulating, Condensate and Vacuum Return	302-7
	g. Miscellaneous Fittings and Equipment	302-7
302-03	INSPECTION	302-8
	a. Planning	302-8
	b. Piping	302-9
	c. Pipe Insulation	302-12
	d. Hot-Water Systems	302-12
	e. High-Temperature Hot Water	302-13
	f. Steam Systems	302-14
	g. Hot Air Heating	302-14

Para.	Title	Page
h.	Heating and Ventilating Units	302-15
i.	Unit Heaters	302-15
j.	Controls	302-16
k.	Boilers and Boiler Plants	302-16
l.	Smoke Connections	302-29
m.	Fuel Storage and Conveying	302-30
n.	Painting	302-32
o.	Testing	302-33
p.	Operating Instructions and Guaranties	302-33

CHAPTER 302
HEATING

302-01. GENERAL

a. This chapter covers material, equipment, and good workmanship practices for the installation of heating systems.

b. The inspector should strive to obtain systems in accordance with the contract requirements that are safe, adequate, and neat, and which function properly with a minimum of routine maintenance.

c. In combination heating-cooling systems designed for year-round automatic air conditioning, coordinate material of this section with Section 303, VENTILATING, AIR SUPPLY AND DISTRIBUTION SYSTEMS, and 304. REFRIGERATION AND AIR CONDITIONING.

302-02. MATERIALS AND EQUIPMENT

a. General

(1) Make sure that each piece of material and each item of equipment has been approved well in advance of its need. When the material and equipment arrive on the job, inspect them very carefully, comparing them with the approved shop drawing and samples.

Check and record nameplate data on all equipment.

(2) Determine that there is adequate space in the room for proper functioning and maintenance of all the equipment.

(3) Reject all damaged materials and equipment and have them removed from the site.

(4) Check the electrical features of equipment and coordinate with the mechanical features.

(5) Determine that provisions have been made for access panels.

(6) Check the required controls and valves for compliance with contract requirements.

(7) Check specification provisions for necessary spare parts and tools for all of the equipment.

(8) See that operations and maintenance instructions are with equipment and are posted on the wall upon completion of installation.

(9) Require proper storage and protec-

tion of all materials and equipment.

(10) Check the noise level of all equipment.

(11) Verify requirements for the installation of flexible pipe connections and vibration eleminators for equipment.

(12) Check the installation of all equipment for compliance with manufacturer's recommendations.

b. Boilers, Furnaces, and Accessory Equipment

(1) Examine pressure boilers for conformance with the ASME Code.

(2) Check for all necessary connections on the boiler.

(3) Check cast iron boilers, if field assembled, for tightness of joints.

(a) All joints should be sealed.

(b) Reject cracked sections.

(4) Inspect refractory furnaces built up on the job for materials and workmanship.

(a) Require expansion joints to be provided. Piping on both sides of expansion joints should be properly guided.

(b) Insure packing to prevent gas or air leakage.

(c) Reject all cracked, chipped or otherwise damaged brick and tile.

(d) Check plastic refractories for placement, thorough ramming, and consistency.

(e) Require refractories to be kept dry.

(f) Inspect for use of refractory mortar in construction of combustion chamber.

(g) Check for air circulation under the combustion chamber floors.

(5) Inspect the application of insulation after all joints are tightly sealed. Check material, thickness, and finish.

(6) Observe accessory equipment operation as feedwater controllers, dampers, pressure and draft gages, flow and pressure

recorders, soot blowers, water columns and boiler blowdown. Check the pressurestat differential.

(7) Check requirement for expansion joint in floor around boiler.

c. Fuel Burning Equipment

(1) Coal, Hand-Fired. Verify installation of grates and operation of dumping mechanism.

(2) Coal, Stoker-Fired. Confirm capacity and operation of feeder, grates, and ash removal.

(3) Oil burners. Check:

(a) Size of burner tips.

(b) Location of electrodes to insure spark in oil spray cone.

(c) Position of gas or oil pilot.

(d) Clearances for removal of burner from furnace.

(e) Burner adjustments.

(f) CO_2 in flue gas.

(4) Inspect gas burners for cleanliness, adjustment, position of pilot flame, and sensing element. Check regulator and controls.

(a) Check blow-out of gas line before connecting to burner or regulator.

(b) Is regulator installed in vertical position?

(c) Are gas vents piped to the outdoors?

d. Draft Fans

(1) Check fans and drivers for anchorage, alignment, and rotation.

(2) Check accessibility of lubrication fittings.

(3) Inspect dampers for operation in compliance with contract requirements.

(4) Inspect bearings for smoothness and overheating.

(5) Check vibration and vibration absorbing mounts.

(6) Inspect insulation application to induced draft fan.

(7) Examine safety control interlocks and air-flow switches.

e. Oil Storage Tank

(1) Check for Underwriter's approval.

(2) Check tank capacity and calibration.

(3) See that tanks have the required openings and the means for proper anchorage.

(4) Check for tank heaters, when required.

(5) Examine paint coating and examine holiday testing.

f. Circulating, Condensate and Vacuum Return Pumps

Inspect for capacity and for method of mounting.

g. Miscellaneous Fittings and Equipment

Inspect drips, traps, valves, coils, elements, convectors, radiators, etc., as they are brought on the job, to make sure that they are of the correct capacity and that they have been approved.

302-03. INSPECTION

a. Planning

(1) Check the availability of codes, reference data and manufacturer's recommendations.

(2) Check with contractor for his detail layouts of equipment and piping which are normally made to coordinate work of the various trades.

(3) Compare nameplate data, piping markings, etc., with requirements.

(4) Provide the proper spacing of equipment to make sure that there is adequate room for piping, ductwork, accessibility for maintenance and that walls behind ductwork can be finished without duct removal.

(5) Notice how the heating system fits into the total job.

(6) Be sure that sleeves of the correct size and material are properly located in floors and walls before they are built.

(7) In spite of all attempts to insure that sleeves, inserts, boxes, and so on, are

all in place before concrete is poured, oversights occur, and it becomes necessary to cut concrete. Any such operation should be approved by the supervisor before it is begun. A cut in concrete wall should be made from both sides of the wall to avoid spalling of the far surface.

b. Piping

(1) Compare piping workmanship with the check list of paragraph 301-02.

(2) Check storage and handling agains paragraph 301-01c.

(3) Inspect for the required type and size of pipe.

(4) Examine the cutting of construction to install piping.

(5) Require provisions for expansion and contraction, and proper anchorage of pipe.

(6) Check the installation of mechanical expansion joints. Do not remove spacers until expansion joints are ready to be installed.

(7) Know that the pitch of the horizontal runs are correct.

(8) Check the position of branch connections.

(9) Be sure that required valves are installed in the correct positions.

(10) Check the method and procedure of jointing pipes.

(a) On threaded joints, check for the use of tapered threads. See that graphite and oil, or an equivalent, are applied to the threads.

(b) On welded joints, check for compliance with approved welding procedures; inspect for defective welds; check type of material of the welding rod; make sure welders have been qualified and are stamping their welds.

(11) See that piping is properly aligned and that there is no strain on joints or on adjacent equipment.

(12) See that proper grade and alignment are maintained and that proper fittings are provided to eliminate air pockets and restrictions.

(13) Check for air valves at all high points and at the ends of mains. Check for

drips and traps at low points. Examine the lines to make sure that condensate cannot accumulate in the lines.

(14) Inspect for required floor, wall, and ceiling plates. Check for type, size, material, and finish.

(15) Watch for the use and proper installation of eccentric fittings.

(16) See that interconnecting piping between boilers conforms to shop drawings and ASME Code. Watch for adequate valves and other special fittings. The means should be provided to valve-off each boiler from the steam header.

(17) Be sure that lift fittings are provided where the gravity flow of vacuum returns is interrupted by a change to a higher elevation.

(18) Clean all supply and return lines before putting them into operation. Check whether contractor has cleaned all traps and strainers after pipe cleaning and before system operation.

(19) Check safety valve discharge pipe for number of ells (restriction).

(20) Check bent pipe for kinks, wrinkles or other malformations.

c. Pipe Insulation

(1) Know locations of pipes required to be insulated.

(2) See that insulation, cotton jackets and bands have been approved.

(3) Check width and type of material and the spacing of bands.

(4) Be sure that all fittings except unions and flanges are insulated.

(5) Be sure that cotton protected sheeting is of the proper weight and that it is neatly applied.

(6) Check for continuity of insulation through walls and floors.

(7) Check that proper thickness of insulation is being applied.

(8) In chilled-water and hot-water combination piping check for vapor seal requirement on boiler piping.

d. Hot Water Systems

(1) Note the installation of balancing valves or orifices in the return connection of each radiator or heating device.

(2) See that contractor balances system as required by plans or specifications.

(3) Insure that threaded openings are provided on converters. See that safety devices and temperature controls are furnished and are in working order. Check test pipe coil for tightness and clearance for its removal. Note drain pipe to outside atmosphere or floor drain from blow-off safety valves.

(4) Check for automatic and manual vents.

(5) Examine expansion tanks for size, conformance to code, protective paint coating, insulation, water level gage, drain and air charging valves.

e. High Temperature Hot Water

(1) Check pumps for:

(a) Leveling, alignment, and stability on foundation.

(b) Lubrication.

(c) Seals for leaks.

(d) Packing adjustment and type.

(e) Pressure retention.

(f) Correct rotation.

(2) Insure that radiant heating coils are accurately placed, firmly secured, and absolutely tight under a hydrostatic test pressure of one and one-half times the operating pressure prior to encasement in construction.

f. Steam Systems

(1) Know details of the type of system required. Make sure it is a two-pipe system.

(2) Check the operation of supply valves to radiator and convector.

(3) Check radiator run-out for pitch.

g. Hot Air Heating

(1) See that flue gas does not contaminate the heated air.

(2) Be sure that return air has free passage to heater unit.

(3) Note damper setting balance of the flow of air.

(4) Check that flexible connections have been installed between furnace and duct system.

h. Heating and Ventilating Units

(1) Require that all component parts operate satisfactorily.

(2) Note access doors for tightness and clearance.

(3) Determine that noise level is within acceptable limits.

(4) Check flexible pipe connections and/or vibration eliminators.

(5) Check rotation.

i. Unit Heaters

Check:

(1) Air distribution.

(2) Noise level.

(3) Controls.

(4) Clearances.

(5) Rotation.

j. Controls

Be sure that the controls are provided, as specified, that they are properly hooked up, and that they will perform the required operation.

k. Boilers and Boiler Plants

(1) General Requirements:

(a) Before rolling in, check the cleaning of ends of tubes and the surfaces of tube holes in drums and headers. Check to assure that new boilers exposed to weather are covered to prevent corrosion.

(b) See that tube-rolling is done by experienced workmen and that all precautions are taken to prevent either under or over rolling. At this stage of erection request technical assistance.

(c) Insure that the boiler inspector is notified when it is time for the hydrostatic test. Secure Certificate of Inspection. Do not permit the installation of any baffles or the setting of refractories until after the boiler has passed inspection.

(d) Affirm that baffles of steel, refractory tile, or monolithic construction are installed gastight but with provision for expansion, and that they will resist dislodgment by "puffs."

(f) Insure that boiling-out operations for the removal of grease, oil, and other foreign matter are performed before boiler is placed "on-the-line."

(g) Insure that space is provided for tube removal and cleaning and for general maintenance of all equipment.

(h) Check to assure that during periods of operation by contractor chemical treatment and blowdown are provided to prevent scale deposits and corrosion.

(2) Settings

(a) Be sure that all settings are constructed with provision for expansion and contraction of both the refractories and the pressure parts. See that expansion joints are sealed to prevent passage of air or gases but are flexible enough to maintain their seal under movement of the structure. Check the entire setting for leaks.

(b) Check solid refractory walls for plumb, level courses and dipped joints. Check grades of refractories used. Chipped, cracked, wet or broken refractory materials should be rejected.

(c) Insure that refractory tile and setting casings are constructed to prevent the excape of gases or the infiltration of air, and that they are installed in accordance with the recommendations of the manufacturer.

(d) Insist that all openings through setting walls are accurately located and of proper size. Check temperature of boiler setting surface against room temperature.

(e) Verify that pipe sleeves for draft gage are clean and flush with interior face of wall.

(f) Inspect uptake damper for correct location, bearing material, and freedom of operation when hot.

(3) Fuel Burning Equipment

(a) Correlate coal stokers with stationary grates for accurate placement and support of the grate bars. See that shaking and dumping mechanism will work freely under operating temperatures.

(b) Evaluate traveling and moving grates for alignment of running parts and guides, tightness of seals, and provision for expansion and contraction.

(c) Note lubrication and protection of motors, gears, and bearings.

(d) Examine all moving parts for operation under temperatures encountered and for loads specified.

(e) Insure that grate design and coal sizing are suitable for each other.

(f) See that stoker feeding mechanism is adjusted to distribute the coat evenly over the grates.

(g) Verify that pulverizers are constructed and installed as nearly dust-tight as possible. Be sure the equipment is firmly secured to foundation. Check units for proper balance and quiet operation at normal operating speeds.

(h) See if pulverizers are adjusted for proper coal fineness. Notice whether heat is applied to the coal in the pulverizer, or that temperatures are obtained prior to entrance of coal to assure satisfactory dryness of coal.

(i) Insure that burners are adjusted for efficient operation, minimum excess air, stable ignition at low rating, and no impingement on furnace walls. Use a boiler test kit when required.

(j) Evaluate the coal feeder for accurate and even operation.

(k) Examine the installation of access and inspection doors.

(l) View magnetic separators for location ahead of pulverizers.

(m) All safety precautions are to be observed in the installation of gas burners and piping. Arrangement of gas valves should be in accordance with ASA Standard Z 21.33.

(n) Burners should be arranged to permit ready inspection and servicing.

(o) Note location of pilot flame. Provision should be made to facilitate manual lighting of pilot flame. Hand torch and receptacle should be provided for each boiler.

(p) See that mixing dampers or valves are adjusted to proportion air and fuel for the most efficient combustion with minimum excess air and stable operation of low rating, with no impingement on furnace walls.

(q) Compare all dimensions of the combustion chamber during construction for agreement with manufacturer's approved shop drawings. Check all materials of construction for compliance with specifications and approved shop drawing. Take physical samples of all tile, insulating plastic, firebrick, etc., for future reference.

(r) Check type and capacity of heaters for grade of oil.

(s) Check relief of excess pressure in pumps.

(t) Test oil piping for leaks.

(4) Draft Fans and Duct Work

(a) See that induced draft fans are provided with cleanout doors.

(b) Note the operation of dampers at high flue gas temperatures.

(5) Blow Down System

(a) Insist that work conforms to applicable codes.

(b) Observe location of vent and discharge lines.

(c) Require that piping provides for expansion and contraction.

(6) Combustion Controls

(a) Inspect equipment for type, capacity, installation, and operation.

(b) Be sure that operating devices are firmly secured to floor, foundations, or other supports and that they operate freely. They should have sufficient power to easily perform their duties.

(c) Note the location and stability of sleeves in setting walls, ducts or breechings for draft piping, thermometers and gages.

(d) Pipe, tubing, and wiring should run neatly and parallel to the lines of building or structure. They should be firmly secured and have proper pitch. See that draft piping is provided with means for removing accumulations of ash and soot.

(e) Verify the operation of safety controls.

(f) See that flame-sensing device is installed in position to sense both pilot and main flame.

(g) Determine that instrument panels are firmly anchored and set plumb. Be sure that wiring, tubing, and piping are neatly arranged in rear of panel. See that nameplates, indicating the function of each instrument, are mounted on the face of the pane.

(h) Secure a written statement from manufacturer's representative to the effect that all equipment of the control system is properly installed and in perfect operating condition before acceptance.

(7) Economizers and Air Heaters

Check for tightness of tubes or plates and for evidence of erosion or corrosion whether integral with the boiler or separate units. Observe performance.

(8) Fly Ash Collectors

Check:

(a) Inspection and cleanout doors for location and adequacy.

(b) Dampers for free operation under all temperature conditions.

(c) Discharge grates for leakage of either ash or air.

(9) Boiler specialties

(a) Notice all trimmings such as water column, steam gage, safety valves, blowoff valves, nonreturn valves, stop and check feed valves and vent valves for type and size. Inspect for installation and setting.

(b) See that safety valve discharge piping does not impose a strain on valve.

(10) Soot Blowers

(a) Determine operating pressure of steam operated units.

(b) Note materials of elements and bearings.

(c) See that wall boxes are accurately

and firmly set and that the operating heads are securely fastened. Insure that each element operates freely and that it may be removed without disturbing tubes or setting.

(d) Check clearance for the removal of soot blowers.

(e) Insure that drainage is provided to prevent moisture from being blown into the furnace.

(11) Check for correct location and installation of test holes in breechings and stacks to allow for periodic measurement of flyash and other particulate matter for air pollution control.

(a) Inspect breechings for gage (thickness) of metal, supports, and insulation.

(b) Examine cleanout doors for tightness, location, and size.

(c) Check expansion joints for tightness and location.

(d) Note calked joint at opening around breeching entering masonry chimneys.

(e) Check guys, bracing or other supports.

(f) Reject damaged or unsuitable brick and radial block. See that all courses are brought up together and bonded.

(g) In reinforcement operation inspect materials and accuracy of placement. Observe especially the lapping of bars.

(h) Evaluate the material and the setting of embedded items for securing ladders, platforms, cables, lights, doors, or other equipment.

(i) Check openings and locations of test holes in breeching. Check cleanout door for size and location.

(j) Check closing and latching of cleanout doors.

(k) See that firebrick lining covers the chimney area and that weep holes are provided at bottom.

(l) Check continuous-pour type concrete chimneys for a smooth, jointless exterior finish.

(m) Determine if ladders are sturdy, securely anchored, and provided with safety cages where required.

(n) Verify that metal vent cap, when required, is firmly secured and coated for prevention of corrosion.

(o) Identify requirement for obstruction lights and lightning protection. Check access to them for servicing.

(p) Insure that chimney is plumb, concentric, and has uniform taper from top to bottom.

(12) Boiler Feedwater

Check:

(a) Type of water treatment for

1. Water available.

2. Pressures and temperatures to be obtained in boiler.

3. Materials and installation.

(b) Scales, proportioning devices, and mixing valves for accuracy and operation.

(c) Installation of tanks and piping for types of material and supports, workmanship, and conformance with contract requirements.

(d) Pressure tanks for conformance with the applicable codes and ASME stamp.

(e) Control apparatus for the installation and operation of all components. Check should be done by the manufacturer's service engineer. Refer to job specifications for necessary tests and reports required, and determine from service engineer the sequence of testing.

(f) Open heaters for the installation of pans, trays, plates, sprays, and other internal parts, as well as for the setting of the control for water level in storage compartment. Be sure that heater vent operates and that the heater reduces the oxygen content in the water to the specified amounts before acceptance. Checking should be done by manufacturer's service engineer.

(g) Closed heaters for compliance with code governing unfired pressure vessels. Assure that clearance is provided for the removal of tubes. Evaluate performance.

(h) Thermometers and gages for accuracy and operation.

(13) Turbines

(a) Inspect equipment for the pressures and temperatures to be applied. Compare with approved shop drawings.

(b) Examine all drains, drips, leakoffs, relief valves, and other required safety devices for operation.

(c) Insure that turbines are firmly secured to foundation, are accurately aligned with driven equipment, and operate without vibration.

(d) See that piping is installed to impose no strain on turbine connections.

(e) Verify that provision is made for expansion when aligning couplings.

(f) Be certain that field-assembled turbines are installed by the manufacturer's erectors only.

(g) Reduction gears must mesh perfectly and operate smoothly and without noise or vibration. Check dowelling after turbines and gears are in perfect alignment.

(h) Evaluate the operation of governors.

(i) Check capacity and steam consumption under various load conditions.

1. Smoke Connections

(1) Examine the size and construction of stacks and flues.

(2) Check the clearance space between stacks, flues, and adjacent building materials.

(3) Inspect the method of supporting and anchoring all smoke connections.

(4) See that cleanout is provided which will allow cleaning of the entire smoke connection without dismantling.

m. Fuel Storage and Conveying

(1) Inspect overhead bunkers for capacity in conformance with specifications. See that all gates are installed dust-tight and that they operate freely. Note the sealing of spaces around top of bunkers and elevators.

(2) Be sure that silos are erected plumb and concentric.

(3) See that courses in tile, brick or block silos are carried up evenly, that horizontal joints are level, and that reinforcement is welded and thoroughly embedded.

(4) Tight joints and reinforcement bands for concrete stave silos must be pulled up tightly.

(5) Check continuous-pour type concrete silo for a smooth, jointless exterior finish.

(6) Determine whether pneumatic conveyors are installed with air and dust-tight joints.

(7) Examine materials and installation of mechancical coal conveyors.

(8) Insure that screw flights do not ride on bottom of trough.

(9) See that bucket, chain, and belt conveyor guides and bearings are carefully aligned.

(10) Evaluate skip hoists for capacity and proper installation, with particular attention to operation of the top and bottom limit stops.

(11) Make sure that housings for all conveyors and elevators are installed with dust-tight joints.

(12) Access doors and connections with chutes and discharge gates should be tightly fitted.

(13) Observe that chutes are installed with sufficient slope to insure free, gravity flow of coal.

(14) Check weighing lorries for capacity, accuracy of weight, and ease of operation.

(15) Verify that vibrating feeders are accurately positioned and adjusted for specified flow of coal.

(16) Be sure that coal crushers are securely anchored to foundation or supports and that grids are adjusted to proper coal size. Ascertain the direction of rotation.

(17) Check coal scales for accuracy of weight and for operation of component parts.

(18) Track and Truck Hoppers - Insure provision for removing water from pits. Inspect hopper grids for size opening and materials.

(19) Note flow of coal of entire conveying system, from unloading hoppers to boilers.

n. Painting

(1) See that equipment contains the correct finish. Watch for abrasions.

(2) Watch for miscellaneous ferrous metal items that are not primed.

(3) Require finish painting as specified.

(4) Identify all pipe runs as specified.

o. Testing

Witness that all required tests of heating equipment are accurately recorded. See that tests are performed by manufacturer's representatives where required. Check tests and verify that tests meet all requirements before acceptance. Report unsatisfactory test results to the supervisor

p. Operating Instructions and Guaranties

(1) See that equipment guaranties and instructions for the operation of equipment are furnished.

(2) Notify supervisor of the readiness of the construction for test and subsequent operation for instructing personnel.

CHAPTER 303
VENTILATING, AIR SUPPLY AND DISTRIBUTION SYSTEMS
INDEX

Para.	Title	Page
303-01	GENERAL	303-1
303-02	EQUIPMENT	303-1
	a. General	303-1
	b. Fans and Air Handling Units	303-2
	c. Power Roof Ventilators	303-3
	d. Gravity Ventilators	303-3
	e. Dampers	303-3
	f. Filters	303-4
	g. Screens	303-6
303-03	DUCTWORK	303-6
	a. Fabrication	303-6
	b. Erection	303-7
	c. Insulation	303-9
	d. Diffusers, Registers and Grilles	303-10
303-04	BALANCING AND TESTING	303-11
	a. Cleaning and Adjusting	303-11
	b. Testing	303-12

CHAPTER 303
VENTILATING, AIR SUPPLY AND DISTRIBUTION SYSTEMS

303-01. GENERAL

Since the ventilating system is largely dependent upon associated equipment, the inspector must closely coordinate this chapter with chapters 302 and 304. The same importance of a thorough knowledge of job plans and specifications applies.

303-02. EQUIPMENT

a. General

(1) It is the inspector's responsibility to determine that all equipment is approved well in advance of its actual need on the job.

(2) Check all equipment delivered to the site for conformance with approved shop drawings. Make sure the necessary rating and test certificates have been furnished.

(3) Closely examine material for any damages. Minor abrasions or rust spots must be cleaned and repainted to match original paint in appearance and in quality. Reject other damages.

(4) Be certain that approved vibration-isolators and flexible connections will be furnished as specified.

(5) Examine the mounting of each piece of equipment for secure installation.

(6) Check equipment for excess noise and vibration.

(7) Do not use dissimilar materials, especially screws, fasteners and flashings with different equipment bases and housing materials.

b. Fans and Air Handling Units

(1) Check rotation of fan before permanent power connection is made.

(2) Check method of drive. If belt driven, check means provided to adjust the motor.

(3) Check the type of motor enclosure.

(4) See that specified seals, sleeves and bearings are provided, and when lubricating type bearings are allowed provide accessibility for lubricating without dismantling fan or disconnecting duct.

(5) Provide a fire-safety switch on return air ducts of circulation systems.

(6) Check for pulley and belt alignment.

(7) See that adequate guards are provided for rotating equipment and belts.

c. Power Roof Ventilators

(1) Provide service accessibility.

(2) Flashing at curbs must be watertight.

(3) Discharged air is not to be directed toward air intakes.

d. Gravity Ventilators

(1) Examine installation for rigidity and weathertightness.

(2) Make sure units are oiled and properly adjusted.

(3) Check the actual freedom of rotation of the blades.

e. Dampers

(1) Backdraft dampers should be installed for each exhaust fan.

(2) Check the actual operation of the dampers. See that dampers do not rattle and that felt strips are provided for backdraft dampers.

(3) Assure that a separate frame is provided in openings on which the dampers will be mounted.

f. Filters

(1) Make sure the proper type of filter is furnished and installed.

(2) Check thickness and method of mounting and supporting.

(3) Provide proper amount of adhesive and washing tank for viscous medium type filters.

(4) Inspect sealing strips.

(5) Provide accessibility for removal and replacement of filters.

(6) Assure that air stream is distributed uniformly over all filters areas.

(7) Observe electrostatic-type filters for operation of warning lights and door interlocks. Check ionizers for loose wires, sparking, and free access.

(8) Inspect automatic sprays for complete washing and spray coverage.

(9) On traveling screen type filters note the operation of screen and oil charge.

(10) On renewable roll media type filters inspect:

(a) Tracking of roll.

(b) Media runout switch.

(c) Timer setting.

(d) Static pressure control.

(e) Tension on media.

(11) See that clean filters are installed upon completion of final tests.

(12) Check specifications regarding requirements for spare filters. This requirement is sometimes expressed as a

percentage of the total of each kind required. Check on the transfer of the spares to the operating agency.

g. Screens

(1) Provide bird or insect screens if required.

(2) Check fabric material and installation of dissimilar materials.

(3) Check mesh size.

303-03. DUCTWORK

a. Fabrication (See SMACNA Duct Manual)

(1) Inspect for type, thickness and shape of sheet material.

(2) Check workmanship and observe lock seams and breaks in ductwork for cracks.

(3) Inspect all joint connections for correct type.

(4) Make sure that the joints are neatly finished and that the duct is smooth on the inside. Any laps should be made in the direction of the flow of air.

(5) Provide adequate bracing and reinforcement of the larger ducts.

(6) Compare the radius of curved duct with the specification requirements.

(7) Slope ratio of transitions should be checked.

(8) Provide air turns and deflectors to eliminate abrupt turns of air with appreciable turbulence.

(9) Check the need for and construction of splitter dampers. Make sure the operating mechanism is accessible; and if exposed in a finished room, the mechanism is to be chromium plated.

(10) Make sure that fire dampers are provided in ducts as required in accord with NFPA 90A or 91.

(11) Check duct for the required test holes and covers.

(12) Check the fabrication of flexible connections.

b. Erection

(1) Examine all fabricated ducts, rejecting any which are not smooth or any which are damaged.

(2) Examine duct hangers for material, thickness, and spacing.

(3) Check specification requirements for the need for stiffeners for wide ducts.

(4) Provide approved flexible connections between ducts and for fan units.

(5) Check rigidity and tightness of such field installed items as dampers and deflectors.

(6) Provide access doors at all fire dampers, automatic dampers, coils, filters, heaters, thermostats, or at any item that requires servicing. Doors are to be airtight, securely fastened and accessible, and able to be fully opened.

(7) Inspect goose necks and rain hoods for method of fastening, flashing and bracing. Goose necks are to be turned away from the prevailing wind.

(8) Provide proper size sleeves where insulated duct passes through wall openings.

(9) When obstructions cannot be avoided, the duct area should never be decreased more than 10 percent, and then a streamlined collar should be used. Larger obstructions require an increase in the duct size in order to maintain as nearly uniform velocity as possible.

c. Insulation

(1) Distinguish between areas requiring flexible type insulation and those requiring rigid or semi-rigid type insulation.

(2) Check the type and thickness of insulation and requirements for vapor barrier.

(3) Check the method of fastening insulation to exterior or interior of duct.

(a) If metal stick clips are used, check the type and spacing.

(b) If wire is used see that corners of insulation are protected from possible damage.

(4) Make a careful check for breaks in insulation and vapor barriers.

(5) See that materials are fire-retardant or noncombustible as required by the specifications.

(6) When equipment casings are required to be insulated, check for proper application. See that application is firm.

(7) Where insulation is subject to mechanical damage, check for protection requirements.

(8) Check for continuity of insultaion through walls and floor, if required.

d. Diffusers, Registers, and Grilles

(1) See that the contractor furnishes a schedule showing all air inlets and outlets.

(2) Inspect diffusers and registers for accessible volume control operator.

(3) Examine specification and installation for integral anti-smudge rings for diffusers.

(4) Check for loose or bent vanes.

(5) Inspect each item for fit, and see that sponge-rubber gaskets are provided when required.

(6) Inspect for the proper operation of registers, dampers, and grille directional-controls.

303-04. BALANCING AND TESTING

a. Cleaning and Adjusting

(1) All ducts, plenums and casings must be thoroughly cleaned of debris and blown free of small particles and dust before supply outlets are installed.

(2) Clean equipment of oil, dust, dirt, and paint spots.

(3) Replace sectional throwaway filters after ductwork is blown out and cleaned.

(4) Lubricate all bearings.

(5) Check tension on all belts and the adjustment of fan pulleys.

(6) Check all fan and belt guards are in place.

b. **Testing**

(1) Before insulating duct test duct for air tightness.

(2) Contractor must provide necessary equipment for air-flow measurements and coefficients for registers and diffusers.

(3) Review contractor's method for recording test data, including comparison to the design air-flows.

(4) Test each outlet for the amount of air quantities required.

(5) Final air-flows must be recorded after all adjustments are made.

(6) If actual air flows result in objectional velocities or distribution, notify your supervisor.

(7) Check all dampers for proper operation.

CHAPTER 304
REFRIGERATION AND AIR CONDITIONING
INDEX

Para.	Title	Page
304-01	GENERAL	304-1
304-02	PIPING	304-1
	a. Refrigerant Piping	304-1
	b. Water Piping	304-2
	c. Installation	304-2
	d. Insulation	304-5
304-03	EQUIPMENT	304-6
	a. General	304-7
	b. Condensers	304-8
	c. Reciprocating Compressors	304-9
	d. Centrifugal Compressors	304-11
	e. Receivers	304-12
	f. Water Chillers	304-12
	g. Evaporative Coolers	304-12
	h. Unit Coolers	304-13
	i. Refrigeration Specialties	304-13
	j. Package-Type Air Conditioners	304-15
	k. Washers	304-16

Chapter 304

Para.	**Title**	**Page**
	l. Humidifiers and dehumidifiers	304-16
	m. Absorption Refrigeration Machine	304-17
	n. Cooling Towers and Ponds	304-17
	o. Pumps	304-19
	p. Insulation	304-20
304-04	CONTROLS	304-21
304-05	TESTING	304-23
	a. Submittals	304-23
	b. Procedures	304-23
	c. Types	304-24
304-06	PAINTING	304-24
304-07	OPERATING INSTRUCTIONS AND GUARANTIES	304-25

[illegible] 304
REFRIGERATION [illegible] AIR CONDITIONING

304-01. GENERAL

This chapter covers Refrigeration and Air Conditioning for both the central and unitary type systems.

Since there is generally a duplication in the requirements for piping and ductwork for this subject and for plumbing and air handling, and since those areas have been covered in previous chapters, it will be necessary for the inspector to be very familiar with the piping area of chapter 302 and the ductwork section of chapter 303.

When the work appears to be beyond the scope of the inspector, technical assistance should be requested promptly.

304-02. PIPING

a. Refrigerant Piping

(1) Determine where copper or black steel will be used, and the type required.

(2) Make sure the piping and fittings have been approved.

(3) Check the method of installing piping.

b. Water Piping

(1) Check the type of piping required for chilled water and condenser water systems.

(2) Determine weight and class of piping.

(3) Make sure the specified and approved piping, fittings and jointing materials are being used.

c. Installation

(1) Utilize paragraphs 301-02 and 301-04 as a check list for fabricating and installing piping. Watch specifically for workmanship, supports, and sleeves.

(2) Be especially careful to:

(a) Make sure the specified solder is used. Check soldering of joints.

(b) See that internal valve parts are removed from valves, and that valves are wet wrapped before soldering.

(c) See that joints are thoroughly cleaned before soldering.

(d) Check on the removal of excess flux and acid after joints are made.

(3) Make sure the proper type flexible connections are installed in the required locations.

(4) See that unions or flanges are installed at all equipment, at control valves, and at other points that will facilitate maintenance.

(5) Check carefully for the proper slope of all lines. Assure slope of refrigerant lines to provide movement of oil through the system.

(6) Check installation for improper configuration of piping. Make sure the installation conforms with the approved drawing. If there is any question about the requirement for the arrangement of piping and if there is no approved drawing, obtain the drawing before allowing the contractor to proceed.

(7) Make sure air vents are installed at high points in water lines and that drains are installed at low points.

(8) Do not allow gate valves to be installed where globe valves are required.

(9) Be sure the balancing cocks are installed to permit proper balancing.

(10) Do not install swing check valves in vertical lines with a downward flow of water.

(11) Check for the installation of such required items as pressure gages, thermal elements, thermometer wells, etc.

(12) Provide adequate number and type of hangers. Hangers on uninsulated copper pipe must be electrolytically coated or made of solid compatible non ferrous metals.

(13) Check for the proper installation of oil traps and double risers in refrigerant lines.

(14) Check valves for pressure setting and discharge locations.

(15) Be sure that refrigerant system is evacuated prior to charging and accomplished according to job specifications.

(16) Make sure the system is charged with the required type and amount of refrigerant.

(17) See that the system is completely checked for leaks. Dry nitrogen must be

used for pressure tests.

(18) Double check to see that there are no unnecessary oil traps.

(19) Vacuum should be broken by charging the system with dry refrigerant for which the system is designed.

d. Insulation

(1) Determine whether the material on the job has been approved for the particular piping being installed. Make sure insulations, vapor barriers, adhesives and sealers are noncombustible or fire retardant as specified.

(2) Note that heated water piping is insulated differently from chilled water piping and from combination chilled and heated water piping.

(3) Check thickness of insulation and of vapor barrier.

(4) Determine that insulation jackets which are exposed to view are paintable.

(5) Examine the requirements for the insulation of flanges, fittings, and valves, and assure compliance with the requirements.

(6) Check the lap and the sealing at joints.

(7) Be very careful to see that there are no breaks in the vapor barrier. Watch for later damages during construction.

(8) Check specification requirements for extending through sleeves in walls, floors, and ceilings; chilled water lines inside cabinets of fan coil units should be covered as required to prevent condensate dripping on floor.

(9) Make sure that pipe hangers are installed over insulation. Metal shields are to be provided between hanger ring and insulation. High density insulation insert shall be installed with a length equal to length of metal shield.

(10) Check for the neat termination and seal of insulation at the end of insulation.

(11) Know the special requirements for insulation and jacketing of piping exposed to weather.

(12) Check the installation, the width, and the spacing of the bands used on pipe jacketing.

304-03. EQUIPMENT

a. **General**

(1) All equipment should be checked to see that it is approved before it is needed on the job. When equipment arrives on the job, it should be checked against shop drawing. During installation, the contractor's work should be checked against the contract plans and specifications, the approved shop drawing, and the manufacturer's recommendations.

(2) Be sure that no damaged equipment is installed.

(3) See that equipment is stored in a manner that will insure that the equipment be like new when installed.

(4) Be sure that all refrigeration equipment is installed strictly in accord with the safety code for mechanical refrigeration.

(5) Check on space requirements for equipment. Obtain an equipment room layout drawing and make sure that adequate clearances are provided for maintenance and operation.

(6) Determine the need for access panels. A common error is the failure to provide the means for pulling condenser and chiller tubes.

(7) Make sure that all rotating parts, such as belts, chains, sheaves, shaft couplings, etc. are covered to protect personnel.

(8) Check the type of motors on equipments, the type of motor starter, heaters in the motor starters, and voltage of motor.

(9) Make sure all equipment is lubricated according to manufacturer's recommendations. This includes motor bearings.

b. Condensers

(1) See that air flow is not obstructed and that wind deflectors are installed, if required, in air cooled condensers.

(2) Inspect water cooled condensers for leaks and proper flow.

(3) Check evaporative condensers for:

(a) Spray coverage

(b) Float valve operation without chatter

(c) Water level

(d) Fan rotation and speed

(e) Pump suction strainer

(f) Liquid discharge line carried full size to first elbow, with a 12-inch to 18-inch drop to receiver

(g) Mesh size of inlet screens

(h) Pan, casing, eliminators, fan corrosion protection, and complete drainage.

(i) Provision for and adjustment of constant bleeding.

(4) For all season air cooled condensers manufacturers recommended installation should be adhered to. Check project plans, specifications, and manufacturers recommended installation to see if condenser flooding or air volume control is required.

c. Reciprocating Compressors

Check for:

(1) Oil, suction, and discharge pressures.

(2) Shaft alignment on direct-driven machines.

(3) Operation of high pressurestat,

low pressurestat, and oil pressure failure switch.

(4) Proper level and viscosity of oil.

(5) Installation of required gages.

(6) Amount, correct type, and dryness of refrigerant charge.

(7) Pressure holding ability upon pump-down.

(8) Isolator deflection and compressor vibration.

(9) Suction strainer screen mesh, and removal of startup felts.

(10) Unloader action.

(11) Compressor speed.

(12) Belt tension and alignment.

(13) Motor amperage under maximum load.

(14) Refrigerant flood back and oil foaming.

(15) Cylinder head overheating.

(16) Rotation.

(17) Automatic oil heater in crank case. Heater should work during shutdown.

(18) Loops in refrigerant piping as loops will permit oil to be trapped.

(19) Damage of equipment compressor - should not be run during vacuum tests.

d. Centrifugal Compressors

Check for:

(1) Alignment of compressor, drive and gear box.

(2) Suction damper or inlet vane operation.

(3) Safety control circuit operation.

(4) Purge compressor operation.

(5) Float valve operation, if furnished.

(6) Oil pump and cooler operation.

(7) Noise and vibration.

(8) Required gages.

e. Receivers

Check for:

(1) Location, if installed on the outside of the building. Do not place in direct rays of sun.

(2) Relief valves of adequate size.

(3) ASME Stamp

(4) Drain, purge valve, liquid level indication, and shut-off valves.

f. Water Chillers

(1) Examine water drains, vents, and correct pass arrangement in direct expansion type chillers.

(2) Inspect for freeze protection safety devices.

(3) Check strength of liquid bleed-off at bottom of flooded chillers. Check adjustment of level control.

(4) Check tubes and shell in brine chiller for type of material.

g. Evaporative Coolers

Inspect for adequate spray coverage, non sagging media, water carry-through, correct water level in sump, and lack of float valve "chatter".

h. Unit Coolers

Check:

(1) For corrosion-protected pan and casing.

(2) Water defrost units for spray coverage with no carryover.

(3) Electric defrost units, for cycle timing in accordance with the job conditions.

(4) Hot gas defrost, for suction pressures and refrigerant charge in accordance with manufacturer's recommendations.

(5) Drainage during defrost cycle.

(6) Cycle timing.

(7) That drain lines are properly trapped on the warm end.

i. Refrigeration Specialties

Check:

(1) Superheat setting of expansion valves and for bulb and equalizer position in accordance with the manufacturer's recommendations.

(2) Solenoid valve for vertical stem, correct direction of refrigerant flow, and manual opener disengaged.

(3) Unobstructed view of sight glass.

(4) Operation of evaporator pressure regulator under light load.

(5) Operation upon start-up of hold-back valve.

(6) Float valves or switches mounted level and at a height which will insure correct liquid level in the evaporator.

(7) Airtightness before opening of refrigerant drier canisters.

(8) Drier; if it is the replaceable type, piping will be arranged to facilitate replacement - 3 valve bypass.

(9) Piping connections of liquid-suction heat exchanger.

(10) That direct expansion coils are installed as recommended by manufacturer.

(11) That pans of fan-coil units are protected against corrosion.

(12) That drain pans are installed under all units, or as needed, to collect condensate.

j. Package-Type Air Conditioners

Check the following:

(1) High-pressure cutout setting.

(2) Compressor hold-down bolts (for shipping) removed.

(3) Drip pan should be watertight and connected to open drain.

(4) Water regulator valve operation, if used.

(5) Installation of air filters and strainers.

(6) Operation of thermostat.

(7) Suction and discharge pressures of refrigeration compressors.

k. Washers

(1) Check the following features of the spray-type air washers:

(a) All nozzles discharging water spray.

(b) No water should carry over from eliminators.

(c) Eliminators must not rattle, and they must be removable for maintenance.

(d) Float valve should not "chatter" on opening or closing.

(2) Check the following features of the capillary-type washers:

(a) Media should not sag in frames.

(b) Wetting of all media.

(c) Water level is to be at correct height.

l. Humidifiers and Dehumidifiers

(1) Examine the humidifiers for supported coil and corrosion-protected pan.

(2) Check refrigeration type dehumidifiers for frosting of cooling coil and for water carry-over.

(3) Check absorption type dehumidifiers for the following:

(a) Solution level and temperature controls.

(b) No solution should carry over from eliminators.

(c) Regenerator duct must be drained of specified material, and correctly sealed.

(d) Damper operation, cycle timing, evidence of "dusting" of the desiccant, and regeneration temperatures.

m. Absorption Refrigeration Machine

Check the following:

(1) Cleanliness of all parts during erection.

(2) Proper materials.

(3) Access for removing tubes from absorber-evaporator and generator-condenser.

(4) Control operation, especially high and low-limit temperature cutouts or condenser water pump interlock.

(5) Operation of purge system.

(6) Unit to be fully charged with water and a nontoxic absorber after installation.

(7) Services of a factory representative for charging, testing, starting the plant, and providing instruction.

n. Cooling Towers and Ponds

(1) Check mechanical-draft cooling towers for unobstructed air intake, fan rotation and speed, belt tension, stacked fill, and weather protection of motor. (Do not allow open fan motors when totally enclosed motors are specified.) See that water-flow through outlet does not form a vortex which draws air in with the water and check operation of water temperature control and drainage devices.

(2) Observe spray ponds for evenness of sprays and for water drift.

(3) Insure provision for an adjustment of constant bleed.

(4) See that mist eliminators are installed when specified.

(5) Insure the installation of overflow and drain piping.

(6) See that the water is at adequate level after operation, and that spray-pump operates.

(7) Check belt alignment and tension.

o. Pumps

(1) Assure that manufacturer's nameplates, equipment, serial numbers, or code stamps are not covered or hidden from view after installation.

(2) Check for anchorage of pump in compliance with contract.

(3) Check alignment of pump with motor and piping.

(4) Make sure that all gages and meters are provided.

(5) See that eccentric reducers, in lieu of concentric reducers, are used in suction piping, and that the flat side is turned up.

(6) Check for adequate support of piping around pump.

(7) Be sure check valve is installed in discharge piping.

(8) Check pump packing. Make sure adequate packing is installed to allow gland take-up.

(9) Check for excess vibration and flexible piping connections if required.

(10) Make sure that the pump motor is weatherproof when specified, and that it is connected to rotate correctly.

(11) Recheck oil sumps after operation, if applicable.

p. Insulation

(1) Types; Check for:

(a) Proper insulation of chilled water pumps.

(b) Insulated converters and expansion tanks.

(c) Insulated condensate drain pans of air units.

(d) Protective finish over such items as pumps, converters tanks, fans, etc.

(2) See that all insulating materials have been approved and that they are of the specified thickness.

(3) Check the method of attaching insulation to equipment.

(4) Make sure that specified reinforcing is provided in plaster finish.

(5) See that plaster beads are installed at the specified corners.

(6) See that plaster has smooth, pleasing finish.

(7) Check on the application of vapor barriers to see that they effectively seal out all moisture.

304-04. CONTROLS

a. Review all control installations with approved control shop drawings, to assure that they are being installed in strict conformance with the drawings.

b. See that dampers are mounted rigidly on rigid supports, and that the correct bearings are provided on the blade axles.

c. Note damper motors while fan is on, and check linkage between damper and motor.

d. Examine valve operations for tight closing.

e. Examine electrical equipment for interlocking.

f. Check on the installation of all required alarm bells.

g. See that freeze-stats are installed as specified.

h. Provide proper electrical current and voltage in the control system. Carefully check the operation of solenoid valve.

i. Locate air compressors to permit tank drain operation and check for cycle time with all controls operating.

j. Verify clean elements in humidistats when the system is started.

k. Evaluate pneumatic systems for air-tightness, restrictions caused by flattening of the tubing, and cleanliness of the system.

l. Inspect electronic systems for grounded shielded cable, and location of amplifiers with respect to magnetic fields, such as large transformers.

m. View graphic panels for damaged plastic, dirt between plastic and back plate, lacing of control wires and access for service to all controls.

n. Verify control instructions, including sequence of operations, and control drawing furnished by the contractor when conducting final acceptance test. Check each function of the controls.

304-05. TESTING

a. Submittals

Be sure the contractor obtains approval of test procedures and other pertinent information prior to testing.

b. Procedures

(1) Make a record of all tests, including such information as who attended, methods and procedures of test, results, and conclusions. Check specifications to determine that contractor is recording sufficient data to comply with requirements.

(2) Before tests are scheduled, see that contractor has proper tools, equipment, and instruments, and gages should be certified and pretested.

(3) See that equipment is thoroughly checked and prepared for tests.

(4) Make sure strainers and filters are clean immediately prior to test.

c. Types

(1) Check the testing of refrigerant piping. See that specified pressure is put on the lines. Make sure all joints are checked, and that leaks are detected, repaired, and retested until found satisfactory. Isolate all items which may be injured by high pressure.

(2) See that hydrostatic test is performed on all water piping. Carefully check to see if there is a loss in pressure during the test.

(3) See that a performance test on the system is run for the duration specified. Make sure needed corrections and adjustments are made as determined during test. See that the contractor records all data required for the performance test.

(4) After sucessful tests, install a new oil charge in compressor. Change oil filters and socks, and provide new cartridge in refrigerant drier. (Oil charge is not required for factory sealed units.)

304-06. PAINTING

a. See that equipment is furnished with the correct finish. Watch for abrasions.

b. Watch for miscellaneous ferrous metal items that are not primed.

c. Require touching up, priming, and finish painting as specified.

d. Apply asphaltic varnish on all hangers and other items not to be painted.

e. Require piping identification and coding as specified.

304-07. OPERATING INSTRUCTIONS AND GUARANTIES

a. See that equipment guaranties, schematic flow diagrams, and instructions for the operation of equipment are furnished and posted.

b. Arrange for future operating personnel to be instructed on the operation of equipment. Make a record of instruction periods, including any complications, instructing personnel, and personnel instructed.

CHAPTER 305
INTERIOR ELECTRICAL

Para.	Title	Page
305-01	GENERAL	305-1
305-02	GENERAL REQUIREMENTS	305-1
305-03	GROUNDING	305-7
	a. Drawings and Specifications	305-7
	b. Visual Inspection	305-8
	c. Grounds to Metallic Water-Piping System	305-8
	d. Bolted Connections	305-8
	e. Exothermic Welding Connections	305-9
	f. Metallic Inclosures	305-9
	g. Incoming Service Conduit	305-9
	h. Grounding Connection	305-9
	i. Ground Rods	305-9
	j. System Neutral and Equipment Grounds	305-10
	k. System Neutral	305-10
	l. Multiple Connections	305-10
	m. Grounding Resistance	305-11
	n. Electrical Continuity	305-11

Chapter 305

Para.	Title	Page
305-04	WIRING METHODS	305-11
	a. Rigid Metal Conduit and Electrical Metallic Tubing (EMT)	305-11
	b. Cable Systems	305-19
	c. Busway Systems	305-20
	d. Continuous Rigid Cable Supports or Cable Trays	305-22
	e. Wireways	305-22
	f. Auxiliary Gutters	305-23
	g. Underfloor Duct Systems	305-23
	h. Movable Partitions	305-24
	i. Conductors	305-25
305-05	OUTLETS	305-27
305-06	DEVICE PLATES	305-29
305-07	RECEPTACLES	305-29
305-08	WALL SWITCHES	305-30
305-09	SERVICE EQUIPMENT	305-31
305-10	LOAD CENTER TYPE PANEL BOARDS	305-32
305-11	PANELBOARDS	305-33

Chapter 305

Para.	Title	Page
305-12	CABINETS	305-34
305-13	FUSES	305-35
305-14	UNDERGROUND SERVICE CONDUITS	305-36
305-15	AERIAL SERVICE	305-36
305-16	MOTORS	305-37
305-17	MOTOR CONTROL	305-40
305-18	MOTOR DISCONNECT MEANS	305-42
305-19	LAMPS AND LIGHTING FIXTURES	305-42
305-20	ELECTRIC WATER HEATERS	305-44
305-21	ELECTRIC HEATERS	305-45
305-22	EQUIPMENT CONNECTIONS	305-46
305-23	TRANSFORMER STATIONS	305-46
	a. Dry Type Transformers	305-46
	b. Transformer Taps	305-46
	c. Liquid-filled Transformers	305-47
	d. Nameplate Data	305-47

Para.	Title	Page
	e. Accessories	305-47
	f. Bushings	305-48
	g. Insulating Liquid	305-48
	h. Grounding	305-48
	i. Ventilation	305-48
305-24	SWITCHGEAR	305-48
305-25	ENGINE GENERATOR SETS	305-51
305-26	ELEVATOR INSTALLATIONS	305-52
305-27	MISCELLANEOUS SYSTEMS	305-53
305-28	TESTS	305-54

CHAPTER 305
INTERIOR ELECTRICAL

305-01. GENERAL

This guide has been prepared to assist the general inspector in obtaining the quality of interior electrical installation required by the job specifications. It is recognized that specialized technical aspects of this subject will require the services of an electrical engineer or inspector. When the work appears to be beyond the scope of the general inspector, technical assistance should be requested promptly.

305-02. GENERAL REQUIREMENTS

a. It is the intent that the electrical installation shall conform to the applicable rules of the National Electrical Code (NEC)*, except where expressly modified by the plans or specifications. This requirement can be found in the general section of the project specification for INTERIOR ELECTRICAL. The appropriate edition will be listed in APPLICABLE PUBLICATIONS. A copy of the applicable NEC should be readily available to the general inspector, and he should be prepared to use it as a reference and an authority. However, the NEC is a minimum standard intended to assure a safe instalation. NEC paragraph references in the text of this guide are to assist the inspector in using the Code and to lend authority to his demands for features not spelled out in the project specification. Project specification references should be verified in the applicable project specification.

---

*National Electrical Code (NFPA #70). Text references are to the 1975 edition. Copies can be obtained from the National Fire Protection Association at 60 Batterymarch Street, Boston, Massachusetts 02110.

b. Watch job conditions at all times to assure that the electrical work is done at the proper time in relation to other parts of the building construction. (NEC 300-18)

c. Determine the existence, extent, and classification of hazardous locations in the project. If such locations exist, the installation therein should be strictly in accord with appropriate sections of the NEC. Do not approve any doubtful material or workmanship (NEC 500 - 503). Do not fail to seek advice if needed.

d. Inspect materials and equipment when delivered to the job for compliance with contract documents and approved shop drawings. If materials are in accord with approved shop drawings but appear to be contrary to specifications, inform your supervisor.

e. Examine both contractor and government-furnished equipment for damage in shipment. Promptly report defective equipment to your supervisor and accept or reject such equipment, as directed.

f. Shop inspection may have been required for some equipment and material. Copies of reports of such shop inspections should be on hand before acceptance of material or equipment.

g. Storage of electrical equipment should be in dry locations, free of dirt, dust, and corrosive fumes, with protection from physical damage. Storage of switchgear, and engine generator units, will usually require indoor storage. Temporary heaters may be specified to keep equipment free from effects of condensation. Equipment installed during construction phases should be protected from dirt and moisture. A requirement for this protection may be found in "special conditions" of the contract.

h. Require the contractor to furnish all layout drawings required by the specifications. Electrical contract drawings should be reviewed and compared with architectural, structural, and mechanical drawings for possible interferences. Examples of this are:

(1) Are the wall switches located with proper respect to door swing?

(2) Does location of wall outlets conflict with installation of baseboard heating units?

(3) Is there interferences with other building construction, such as pipes, ducts, overhead doors, sliding

doors, accessibility, etc.? Especially check equipment room layout.

(4) Is relocation of ceiling lighting outlets required, especially in utility and boiler rooms, to avoid interference with mechanical equipment?

(5) Will transformers, bus duct or switchgear be subjected to moisture from overhead utility piping?

(6) Have suspended ceilings been lowered, making lighting fixture clearance from floor inadequate?

i. Temporary electric service will generally be required during the construction period for lighting, power, and sometimes heat. The contractor should make early arrangements for such service to prevent construction delays; and temporary installations will be located so as not to interfere with operation of existing facilities or permanent construction.

(1) Temporary open wiring should be guarded or isolated by elevation. Types NM or NMC (Romex) are suitable for temporary wiring when guarded or isolated by elevation. (NEC 320, 336).

(2) Portable and extension cords shall be an Underwriter's approved type for the usage. Hard service cords Type S, SO, or ST are recommended for this service. Types NM or NMC are not approved as portable cables. (NEC $\overline{400}$).

j. Use by the contractor of equipment and facilities permanently incorporated in the structure should be carefully watched to see that circuits and equipment are not overloaded and that all work is left in essentially a new condition. All lamps used for temporary lighting shall be removed when construction is completed, and new lamps shall be installed. (Project specification: Lamps).

k. A list of required equipment should be prepared prior to start of work. This will insure timely approval and will alert the inspector if the contractor has not procured all equipment.

l. Check shop drawings for all equipment having electrical connections to be sure that rough-in conduits and circuits are correctly sized and located.

m. Manufacturers' representatives are sometimes required to assist field and contractor personnel in the installation, assembly, testing and/or initial operation of electrical equipment. Be sure advance arrangements for such services are made by Resident engineer or contractor so that the representative is on hand when needed. Maintain complete record of all adjustments and tests made during installation and start-up, and of an peculiarities of the equipment which may be of use to those responsible for its operation and maintenance. Turn copy of record over to your supervisor for delivery to the owner. Retain a copy of all records for job file.

306-03. GROUNDING (NEC 250 and Project Specifications: Grounding)

a. Drawings and Specifications should be examined carefully to determine the nature and extent of the grounding system and the requirements for separate grounding of equipment and structures.

b. Visual Inspection should be made of all ground-system conductors, connections and electrodes as the work progresses.

c. Grounds to Metallic Water-Piping System should be made on the street side of the meter. Where this is impracticable, full size jumper connections should be made around any piping system element which can be removed. (NEC 250,112(a)).

(1) Make sure that when the water piping system is used for a ground, the water pipe is a metallic pipe and that no insulating fitting has been interposed in the pipe between the ground wire connection and earth. (NEC) 250-81).

(2) Where metallic water main is not available, driven ground electrodes will be provided in conformance with specifications. (NEC) 250-83, and Project Specifications: Ground Rods).

d. Bolted Connections should be examined to make sure that they are tight and that contact surfaces are cleaned and dry. Contact surfaces will be metal-to-metal. Painted surfaces should be cleaned to bare metal.

e. Exothermic Welding Connections will be made in strict accordance with the manufacturer's instructions and will employ the proper type and size of mold for the type and size of connection made.

f. Metallic Inclosures for ground wires shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting. (NEC 250-92(a)).

g. Incoming Service Conduit must be grounded by lugs, pressure connectors or clamps. Locknuts and bushings are not acceptable for grounding service conduit. (NEC 250-32, -71(a) and -72).

h. Ground Clamps for connection to water pipe should be compatible with the pipe (NEC 250-116).

i. Ground Rods

(1) Check size, length, and material of ground rods or electrodes against contract drawings and specifications. (NEC 250-83, Project specification: Grounding).

(2) If suitable water pipe is not available, and if ground rods cannot be driven to a minimum depth of 8 feet, other means of establishing a ground must be utilized. (NEC 250-83 through 86).

j. Grounding Conductor should be joined to grounding electrodes as shown on drawings (NEC 250-112). Some special electronic facilities may require additional isolated grounding electrodes.

k. System Neutral (Grounded Circuit Conductor) should be grounded (connected to the grounding conductor) on supply side of the service disconnecting means (main service switch(es)). This connection should be made within the service entrace equipment enclosure. (NEC 250-23, -52. Project Specifications: Grounding).

l. Multiple Connections

The connecting of more than one grounding conductor to an electrode by a single clamp is prohibited, unless the clamp or fitting is of a type specifically designed and approved by the Underwriters' Laboratory for such use. (NEC 250-115).

m. Grounding Resistance should not exceed specification limits and should be verified by instrument measurement. (Job Specification or NEC 250-84).

n. Electrical Continuity should be verified throughout system, usually by visual inspection.

305-04. WIRING METHODS (NEC 300)

a. Rigid Metal Conduit and Electrical Metallic Tubing (EMT)

Check to determine requirements and limitations on use of rigid conduit or EMT (and special finishing or coating material. (Steel with zinc coating or galvanizing is standard) other materials may be allowed or required.) (NEC 346, 347, and 348).

(1) The project specifications generally require the service entrance raceway to be rigid metal conduit.

(2) Check size of installed conduit against plans and specifications and determine adequacy for number and size of

conductors to be installed. Refer to tables in NEC. (NEC 346-5,6 and Project Specifications).

(3) Check minimum size of conduit permitted by specifications for both electrical system and communication system. (NEC 346-5).

(4) Check to be sure that all required conduits are in place before on-grade slabs are placed.

(a) Generally, for slab-on-grade construction conduit must be placed under the slab and must be rigid type. (Check plans and specification.)

(b) Check project specifications for requirement that for stub-ups, couplings be installed at finished floor level for free standing equipment. (Project specification: Conduits).

(c) Exposed conduit should be installed so that bent portion of stub-up will not extend above floor level.

(d) Be sure that all buried conduit has been surface treated as required by specifications. (Project specification: Conduit and Tubing Systems).

(5) Inspect for damage and deformation of conduit systems. (NCE 346-10 and Project Specifications: Changes in Direction).

(6) Is conduit system to be installed concealed or exposed? Check project specification and plans.

(7) Check for the use of the proper type of conduit fittings, i.e., concrete-tight, rain-tight, cast fittings; expansion joints. (NEC 348-8).

(8) Check for installation of sleeves for future work in foundation walls and floors during correct stage of construction.

(9) Check maximum number of bends in any single conduit run. Do not exceed:

(a) Electrical System - 4 (90°) bends. (NEC 346-11, 347-14, 348-10).

(b) Communication System - Check project specifications for requirements.

(10) Make sure that all the conduit required for circuits involving equipment furnished by other sections of the specifications and approved shop drawings, as well as the electrical sections, is installed prior to placing of concrete, closing in walls, ceilings, etc.

(11) Check for bushings on ends of conduit. Bushings are not usually required on EMT fittings, because EMT connectors should have smooth internal surfaces. (NEC 346-8).

(a) Check for use of insulating bushings. (NEC 373-6(c)).

(b) Check for use of double locknuts when insulating bushings are used. (NEC 373-6(c)).

(c) See that locknuts, bushings, couplings, and connectors are made up tight to insure ground continuity.

(12) See that field cuts of conduits and EMT are made square , ends reamed or filed, and cleaned of oil and filings. (NEC 346-7, 348-11: Project Specifications).

(13) Use of running threads is not permitted at couplings. (NEC 346-9).

(14) Correlate location of conduit terminations against approved shop drawings, equipment and building plans.

(15) Tubing and conduit should be securely fastened in place at intervals required. Means of support provided should be in accord with specifications and NEC requirements. (Project specifications, NEC 348-12, 346-12). Note: Project specifications may require more frequent support than NEC.

(16) Exposed conduit runs are to be installed parallel or perpendicular to walls and structural members. Vertical conduit runs should be plumb.

(17) Conduit runs in wet areas are to be spaced off the surfaces of the structure at least 1/4". (NEC 300-6).

(18) Minimum radius of bends of conduit should be in accordance with table in the NEC. (NEC 346-10, 348-9). This table is based on utilizing conductors

with 600-volt insulation. For cables with higher voltage ratings, and special cables such as telephone cable, consult manufacturer's recommendations for minimum radius of bend.

(19) Check for supporting of vertical raceways at each floor level of multistory buildings. (Project Specifications).

(20) Install galvanized pull-wires in empty conduits when required by design or specification.

(21) Verify the use of corrosion-resistant materials in areas where corrosive influences exist. (NEC 300-6; Project Specifications).

(22) Require means for prevention of entrance of foreign matter in conduits during construction. (Project specifications).

(23) Use approved flexible conduit, standard or liquid tight, for connections to motors installed on slide rails, resilient mounts, those subject to vibration, and eleswhere as specified. NEC 350,351; Project Specifications). Minimum size is 1/2" except as allowed in NEC 350-3, and a bonding jumper may be required.

(24) In areas classified as hazardous, be sure that installation is strictly in accord with Project Specifications and applicable NEC articles 500 through 517. All questions should be referred to qualified personnel. For Class 1, Division 1 areas, the following items should be carefully verified:

(a) Only threaded rigid metallic conduit, or MI cable with approved connectors can be used, (NEC 501-4(a)) and threaded joints must be made up wrench-tight, (NEC 500-1), unless a bonding jumper is installed.

(b) At least five full threads must be engaged at each threaded joint. (NEC 501-4(a)). All field made threads must be tapered (NEC 500-1).

(c) All fittings, fixtures, boxes. and inclosures must be specifically approved for the hazard classification involved. An Underwriter's approval seal is generally affixed to the equipment. If not, secure other firm verification of approval.

(d) Explosion proof fittings, boxes and inclosures have screw or ground joints at openings. Be sure that surface of ground joint is clean, unscratched and smooth, so that the mating surfaces make intimate contact throughout their area. Covers must be tight and gaskets are not to be used.

e) Be sure that all required seals are installed in the correct location and that they are of the correct type. (NEC 501-5 and 502-5).

(f) Check the mounting method of equipment to be sure that no holes have been drilled into the interior chamber of an explosion proof inclosure.

(g) Be sure that all flexible conduits bear the Underwriter's seal of approval for the hazard involved.

(h) See that proper type sealing compound has been installed in all sealing fittings. Follow manufacturer's recommendations. (NEC 501-5(c)2).

(25) Where rigid non-metallic conduit is installed under the specification it should be installed in accordance with NEC 347 and all special requirements of the Project Specifications.

(26) Provide conductor support in long vertical conduit runs. (NEC 300-19).

b. Cable Systems

(1) Mineral insulated metal sheathed cable, Type MI, will be installed in accordance with Article 330 of the NEC and Project Specification requirements.

(2) Aluminum sheathed cable type ALS will be installed in accord with Article 331 of the NEC and Project Specification requirements.

(3) Metal clad cable Types MC and AC (commonly called "BX") should be installed in accord with Project Specification requirements and Article 334 of the NEC. See that insulating bushings or equivalent protection are provided between the conductors and the armor at terminations.

(4) Non-metallic sheathed cables, Type NMC and NM, commonly called "Romex", should be installed in accord with Project Specification and Article 336 of the NEC.

(a) Type NM cable must not be used when non-metallic sheathed cable is installed in the cells of masonry block walls which are exposed or which are subject to excessive moisture or dampness. This includes exterior masonry walls. In dry, non-corrosive locations, type NM may be used. NMC is applicable in wet locations. (NEC 336-3).

(b) See that nails will not be driven into cable. Protecting plates may be required. (NEC 300-4).

(c) See that ground wire is properly fastened at terminating points and outlet boxes. Attach to each box of fitting by securely fastening the wire to the intended screw or with an approved grounding device. (NEC 250-114).

(d) See that cable is secured as required by the National Electrical Code, within 12" of every outlet box or fitting and otherwise at intervals not exceeding 4 1/2 feet. (NEC 336-5).

(5) When authorized by the Project Specification, service entrance cable, Types SE, and USE should be installed in accord with NEC 338.

c. Busway Systems (NEC 364; Project Specifications).

(1) Support busways at specified intervals. (NEC 364-3; Project Specifications).

(2) Install swaybraces when needed to limit lateral movement of busway. (Project Specifications).

(3) Busway position, vertical or horizontal, will determine whether plugs are installed on the sides or on top and bottom. If plans do not indicate desired position, determination of appropriate location should be made.

(4) Install busway runs in straight alignment, parallel to floors and walls, with sufficient space either above and below, or on both sides, to permit installation, operation and servicing of bus plugs.

(5) Check to be sure that types of duct furnished are in accord with specification. Check conductor metal, inclosure type, duct type, wall flanges, and fire stops.

(6) Ground duct housing. (NEC 250-33).

(7) Vertical riser sections up to 6 feet above the floor must be unventilated type. (NEC 364-4).

(8) Check plug-in features and tap off devices against specification.

(9) Check on trolley busways, trolleys, brushes, contact rollers, and flexible cables for no binding and good contact.

(10) Component sections are to be legibly marked with voltage and current ratings and manufacturer's name. (NEC 364-14).

(11) Installation and furnishing of busways usually require that the contractor verify field dimensions. Be sure that timely ordering of busway is not delayed.

d. Continuous Rigid Cable Supports, or Cable Trays are installed to support cables. Only certain specified cables may be installed and loading of support is limited. Continuous rigid cable supports should be installed in accordance with the Project Specification and NEC 318.

e. Wireways or Enclosed Troughs are installed to house and protect wire and cable. In general, wires of the building wire type, such as TW, may be installed in approved wireways. The installation should be made in accord with Project Specification and NEC 362. Particular attention should be paid to NEC 362-5, which limits the number of conductors approved for wireway installation.

f. Auxiliary Gutters

The gutters commonly used for interconnecting large panels and switches fall under this article. Installation should comply with NEC 374.

g. Underfloor Duct Systems (NEC 354, 356).

(1) Install underfloor raceways of steel construction parallel with floor construction, and in straight alignment.

(2) Check to see that sufficient setting depth is available for junction boxes. These are the deepest elements of underfloor raceway systems.

(3) Check for tight joints between underfloor raceway sections and at junction boxes to keep water out of raceway systems. (NEC 354-13, 356-9).

(4) Inserts of both the preset and after-set type will be mechanically secured to the underfloor raceway and set flush with the floor. (NEC 354-14, 356-10).

(5) Splices and taps in underfloor raceway systems will not be made in outlets at inserts, but only at junction

boxes and in header access units of cellular floor raceways. (NEC 354-6; and 356-6). (Tentative Interim Ampt. #127 to NEC).

(6) Provide markers at ends of underfloor raceway runs. The National Electrical Code stipulates minimum requirements, but the plans and specifications may require more. (NEC 354-9, 356-8).

(7) Install end caps at ends of all underfloor raceway systems. (NEC 354-10).

(8) Check tap-off locations to cabinets, panel boards, and receptacles against drawings.

(9) Verify from shop drawinqs relative positions of services in compartments, to be uniform throughout system.

(10) Check cross-sectional dimensions for adequate size. (NEC 354-5, 356-5; Project Specifications).

(11) Be sure that grounding continuity maintained at all connections in the system. (NEC 250-75).

h. Movable Partitions, kitchen vent hoods and similar enclosures, unless specifically approved as raceways, cannot be used as enclosures for general wiring conductors. Instead raceways (such as conduit) must be installed; or else cable (such as type MI) appropriate for the application must be installed.

i. Conductors (NEC 310).

(1) Check type of insulation and jacket, conductor material, conductor size and stranding in each raceway. (Project Specifications).

(2) Observe pulling of wires and cables to detect damage to sheaths, jackets and insulation. This damage is usually caused when runs are "paid out" in a debris-laden area and then stepped on, or by raceways having sharp edges or contamination. Pulling-eyes or cable-gripping devices will be required for large cables.

(3) Install all conductors of a circuit, including neutral, in same raceway in conformance with NEC limitations. (NEC 300-20).

(4) Connections and joints will be clean and tight, with approved pressure-

type connectors, and made in junction and outlet boxes, not in raceways. (NEC 110-14, 300-15).

(5) Connectors, lugs and clamps used to connect copper and aluminum conductors must be suitable for use with the conductor material to prevent galvanic corrosion. (NEC 110-14).

(6) Use only white identified conductors for the grounded circuit conductor. Neutral (white) conductor of the wiring system will be insulated throughout. (NEC 200-7). Conductors having white identified coverings should only be used as the grounded circuit conductor except as allowed in exceptions 1 thru 4 in NEC 200-7.

(7) When a grounding conductor for equipment is run with circuit conductors it shall be bare, or green covered. (NEC 250-57(b)). Project specifications may require covered wire.

(8) Enforce color coding of conductors of branch circuits. Note that all circuit conductors of a color must be connected to the same feeder. (NEC 210-5; Project Specifications).

(9) When branch circuit conductors extend thru fluorescent light fixtures mounted end-on-end come within 3" of ballast, it is necessary to use 90°C wire such as RHH or THHN.

(10) Check that branch circuit wir is not undersized. Specification may require increased wire size when runs from panel board to center of load equal or exceed 100 feet for 120 volt circuits or 230 feet for 277 volt circuits.

(11) See that correct fixture wirir installation is made (NEC 410-22 to 32).

305-05 OUTLETS

A. Check for requirements of cast boxes in exposed work, exterior work, wet locations, and hazardous locations. (Project Specifications).

b. Require hub-type cast boxes when specified. (Project Specification.)

c. Check size of junction and pull boxes. (NEC 370-6, 18, 20).

d. Do not permit overcrowding of boxes with excessive number of conductors. (NEC 370-6).

e. Check identification requirements of power and control conductors at terminals and in pull boxes and junction boxes. Feeders should be tagged to indicate electrical characteristics, circuit number, and panel designation. (Project Specifications).

f. Check for rigid support of boxes. (NEC 370-13).

g. Fit concealed boxes into walls and ceilings. On non-combustible construction the front edge of box should be within 1/4 inch of finished surface, and on combustible construction flush with finished surface. (NEC 370-10).

h. On any masonry or dry wall, work required for installation of outlet, pull, or junction boxes is to be done by skilled workmen. The masonry section of the specifications requires the cutting of block for fitting installed items. Electrician should not be permitted to chop away masonry or dry wall work. Coordination is necessary between the electrical trade and masons and carpenters to effect a suitable installation. (Project Specifications).

i. Check for air space between box and wall or supporting surfaces in wet locations where surface-type units are used. (NEC 300-5).

j. Are outlets exposed to the weather, a weather-proof type? (NEC 370-5; Project Specifications).

k. Pull and junction boxes shall have free access. (NEC 370-19).

305-06. DEVICE PLATES

See that device plates are of specified material and finish and that all surfaces are in contact with wall. (Project Specifications). On surface mounted boxes, the plates should be compatible with the box and without overhanging corners.

305-07. RECEPTACLES

a. Check all receptacles to be sure that specified voltage, ampere, color, slots, etc., are furnished. Also be sure that plug is furnished if specified.

b. Be sure that grounding continuity is maintained between grounded metal box and receptacle and that bonding jumper is installed when required. (NEC 250-74).

305-08 WALL SWITCHES

a. Check wall switches for proper ampere rating, voltage rating, and type. Usually "A-C only" is required. AC only switches are marked "AC" or "AC only" on yoke, never "AC/DC". They can be used for alternating current only. (Project Specification and NEC 380-14).

b. Wall switches will be in hot leg of circuit, not in neutral, and should be installed with the "on" position "up". (NEC 380).

c. Check for requirements of installing pilot lights on switches. (Project Specifications).

305-09. SERVICE EQUIPMENT

a. Check to be sure that proper type of enclosures are furnished (such as drip-proof, totally enclosed, etc.). (Project Specifications).

b. Standard.NEMA designations are used to describe various enclosures. The designations are as follows:

NEMA-I - General Purpose
II - Drip Tight
III - Weather Resistant
IV - Water Tight
V - Dust Tight
VI - Submersible
VII (A,B, - Hazardous Locations,
C, or D) - Class I, Air Break
VIII (A,B, - Hazardous Locations,
C, or D) - Class I, Oil Immersed
IX (E,F, - Hazardous Locations,
or G) Class II
X - Bureau of Mines, Explosion
Proof
XI - Acid and Fume Resistant
Oil Immersed
XII - Industrial Use

"Weatherproof" is defined in the NEC as "so constructed or protected that exposure to the weather will not interfere with successful operation." (NEC 100).

c. Check whether fusible-type or circuit-breaker type of service switch is required. (Project Specifications).

d. Check that the service-switch enclosure is bonded to the grounding system. (NEC 230-63).

e. Check voltage rating and ampere rating of switch. Also circuit breaker trip and fuse sizes and interrupting capacities. (Project Specifications and Plans).

305-10 LOAD CENTER TYPE PANEL BOARDS

Load center type panel boards are sometimes authorized for less critical applications compared to regular panel boards. The following may not be required in load center type panel boards:

(1) Galvanized cabinets
(2) Four-inch minimum width gutters
(3) Locking type doors

Compliance with Project Specifications, and NEC 384-13 through 19 is required.

305-11 PANELBOARDS

a. Inspect plug-in panel board devices, if authorized, to determine tightness of fit.

b. Check loads on panels to be sure of approximate balance among the phases. This is best done by use of clamp-on type ammeters on feeders while panel is carrying its normal load.

c. Be sure panel board typed directory is properly filled out so that areas and devices served can be quickly identified. (Project Specifications).

d. Circuit-breakers, switches, and fuses in panel boards should be inspected to determine that they have correct number of poles, proper voltage, current-rating, and proper interrupting capacity. Refer to contract drawings and project specifications.

e. Check panel boards for inclusion of blanked-off spaces for future circuit-breaker installation. Space to be adequately sized for the rating of future circuit-breaker. Also see that spare breakers required are in place in addition to blanked-off spaces.

305-12. CABINETS (NEC 373; Project Specifications).

a. Check on size of gutter space. A minimum of 4 inches is required for panelboards. Load centers should be in accordance with NEC 373-6(a).

b. Telephone cabinets are to be checked for inclusion of backboard painted with insulation varnish.

c. Compare size of telephone cabinets against contract drawings.

d. Mounting is to be rigid and independent of the support by conduits. In damp locations, there should be 1/4 inch minimum air space at back of panel. (NEC 373-2).

e. Connections to conduits are to be tight, assuring electrical continuity. (NEC 250-71 through 75).

f. Look for special features of construction and installation for areas other than normal, such as hazardous, wet, etc. (NEC 110-11).

g. Examine for galvanized metal construction.

h. Check mounting height of panelboard cabinets. Distance from center of top switch or circuit-breaker to floor should not exceed 6 feet, 6 inches. (Project Specifications).

305-13. FUSES (NEC 240-6).

Inspect for the following:

a. Specified voltage rating

b. Specified amperage and interrupting rating.

c. Non-renewable cartridge types for over 30 AMP. capacity. (Project Specifications).

d. Is dual element time-delay fuse or current limiting fuse required? (Project Specifications).

305-14 UNDERGROUND SERVICE CONDUITS (NEC 230-30 and 31).

a. Check detail requirements of plans and specifications. (Project Specifications).

b. Check requirement for painting or coating of conduits. (Project Specifications).

c. Check method and location of termination of conduit ends and grounding. (NEC 230-63).

d. Seal building ends of raceways entering from UG distribution system.

305-15 AERIAL SERVICE

a. Locate the splice between service drop (NEC 100) and service entrance (NEC 100) conductor at a level lower than the service entrance fitting (head), and bend conductors to form a "drip loop" at the entrance fitting. These precautions will prevent entrance of water into the service equipment. (NEC 230-52).

b. Support aerial service-drops on buildings, providing required clearances from ground, building openings, and from roof where service crosses roofs. (NEC 230-24).

c. Service-drop cable type is to be in accordance with specification requirements. (NEC 230-22; Project Specifications).

d. If connections are aluminum to copper, insure that the type of connectors specified (usually tinned bronze) are utilized and that anti-oxidant compound is properly applied, if specified.

305-16. MOTORS

a. Check motors for conformance with NEMA classification standards. NEMA classification is according to mechanical protection and methods of cooling and is in two categories namely open machine and totally enclosed machine. Installation should be made in accordance with project specifications.

b. Check motors to see that proper terminal connections are made for the operating voltage. A connection table should be securely attached to the motor by the manufacturer if several alternate connections are possible.

c. Be sure motor revolves in direction correct for driven device. Usually an arrow is placed on fans and pumps to show correct directions of rotation.

d. Check reversing types of motors and multi-speed motors to insure that direction of rotation and speed of motor corresponds to setting of control.

e. Make ground connections of motor enclosure through conduit system or by separate grounding conductor. (NEC 430-141, 142).

f. Check motor against specifications and approvals for class of insulation, starting torque characteristics, class, and design.

g. Check motors for proper voltage i.e., when 416 V, three-phase is specified, do not permit substitution of 440 V, three-phase, and vice versa. When 208V, three-phase is specified, do not permit substitution of 230 V, three-phase and vice versa. Proposed substitutions should be referred to an electrical specialist.

h. Note conditions of windings; to be free from moisture and dust. See that appropriate provisions are made to protect equipment prior to turn-over of project.

i. Motors should be operated under connected load to determine following operating characteristics:

(1) Voltage and current to detect possible overloaded conditions.

(2) Speed of motor.

(3) Direction of rotation.

(4) Overheating.

(5) Vibration.

(6) Abnormal sounds or odors.

If connected load is not possible, refer to Resident Engineer. This normally can be done in conjunction with test of driven equipment.

j. Connect motors subject to vibration, and motors on adjustable slide basis, with flexible conduit. Liquid-tight or explosion-proof flexible conduit may be required by installation conditions. Bonding jumpers may be required (Project Specifications; NEC 350, 352, 501-4(a)).

k. Motors installed in hazardous locations are to bear an Underwriters Laboratory nameplate, indicating the classification of areas in which the motor is approved for use.

l. Check lubrication requirements of motor prior to motor operation. (Manufacturers Instructions).

305-17. MOTOR CONTROL

a. Check with the contractor to assure that all motor controllers required by all sections of the specifications have been ordered. Quite often, controllers are not ordered due to disputes between subcontractors. The inspectors should insure that the prime contractor has made necessary arrangements to insure timely procuring of motor controllers.

b. Check motor controllers for:

(1) Horsepower, voltage and current rating at least equal to the rating of the motor which it controls.

(2) Automatic control devices such as thermostats, float or pressure switches directly used as motor controllers, should be adequately rated.

(3) Magnetic-coil voltage rating must be the same as the control-circuit voltage (may b different from the motor voltage).

(4) Selection of proper motor overload heaters; based on the nameplate full-load current of the motor, ambient temperature of controller location, temperature-rise limit of motor. Refer to instruction sheet pasted on inside cover of motor controller. Determine if automatic or manual reset is required for overload protection. (NEC 430-34). (Project Specifications).

(5) Requirements for furnishing reduced voltage starters. (Project Specifications).

(6) Excessive humming or noise under operating conditions.

(7) Requirements for furnishing pilot circuit devices such as "Hand - Off - Automatic" selector switches, pilot lights. (Project Specifications).

(8) Make sure that three-phase motors are provided with three-element overload relays, if required by Project Specifications or NEC Table 430-37.

(9) Be sure control inclosure is as specified in Project Specifications and is suitable for conditions of installation.

(10) Spare interlocks, if specified.

(11) Shipping blocking has been removed.

(12) Control and safety devices should be wired into the "hot leg", not the neutral leg if control circuit is grounded.

305-18. MOTOR DISCONNECT MEANS

a. Disconnecting means that open all ungrounded conductors will be provided for motor driven equipment installations. By locking provisions or by being "in sight" the disconnect(s) will provide protection for persons working on control, motor, and driven equipment (NEC 430-101 thru 113, 430-86).

b. Ratings of switches are to be checked against contract specifications.

305-19. LAMPS AND LIGHTING FIXTURES

Lighting fixtures should be examined for:

a. Chipped porcelain cracked glass and plastics, bent louvers, over-all finish, detachable sockets on RLM dome fixtures (when specified) and "push type" sockets on open fluorescent fixtures (when specified).

b. Required lamp wattage and color characteristics.

c. Ballasts for fluorescent and mercury-vapor lamps suitable for circuit voltage and of high power-factor type; overload protection for ballasts, if specified ballast should be suitable for low temperature operation.

d. Plumb installation and horizontal and vertical alignment.

e. End-caps, canopies, louvers, side panel guards, globes in place and tight, glass side panels, if specified. Acrylic plastic lens when specified.

f. Aiming of floodlights and all other adjustable fixtures.

g. Lamps that are to be installed for the project shall be new, and installed just prior to completion. (Project Specifications).

h. Storage battery powered emergency lighting sets should be checked for requirements of Underwriters listing and other features. They should be permanently installed strictly in accordance with project specifications. (NEC 700).

i. Emergency lighting circuits should be installed in accordance with project specifications and NEC article 700. Circuit wiring should be kept independent of all other wiring (NEC 700-17).

j. End to end mounted fluorescent fixtures must have Underwriters approval for mounting end to end.

305-20 ELECTRIC WATER HEATERS (Project Specifications).

a. Check for the required number of heating elements.

b. Check to determine that each heating element is controlled by a seperate thermostat.

c. Check for manual-reset type hi-limit cutout. Hi-limit cutout to open all electrical connections to all heating elements.

d. Voltage rating of heaters must be in accordance with specification requirements. 240 volt units, if operated on 208 V, will only deliver approximately 75% design heating capacity.

305-21 ELECTRIC HEATERS

a. Check voltage rating of equipment furnished.

b. Check wattage rating of heater. (Project Specification or Design).

c. Check to see whether a high-limit switch is required. (Project Specification).

d. Check physical requirements of heater. Embedded elements are usually specified.

e. Heaters for hazardous areas are to bear a tag indicating Underwriters Laboratories approval.

f. A functional test is required on electric heaters.

g. Check thermostats for range of operation, differential, locking facilities, thermometer, and lock-shield requirements. (Project Specifications).

305-22. EQUIPMENT CONNECTIONS

a. Refer to applicable paragraphs of this chapter.

b. Check plans and specifications for any special features.

c. If Government-furnished equipment is involved, insure the timely availability of all connection drawings.

305-23. TRANSFORMER STATIONS (NEC 450)

a. Dry Type Transformers

Check enlosures for indoor or outdoor service. Install so that air circulation will not be restricted around the transformers. Close-to-ceilings installations should be avoided. (NEC 450-21).

b. Transformer Taps

Connect to produce specified voltage under normal load.

c. Liquid-filled Transformers

Check to see that they are filled to proper level. Level mark is indicated on transformer.

d. Nameplate Data

Check against specification requirements and approved shop drawings. (NEC 450-10).

e. Accessories

Check liquid-filled transformers for compliance with specifications or with specified standards. Such include: Connections for sampling, draining and filtering of insulating liquid; level gage; thermometer; pressure and vacuum gages; external tap changer; provisions for jacking, rolling and lifting; provisions for pole, platform or slab mounting; provision for grounding of case and windings; alarm devices actuated by abnormal liquid level, temperature or pressure; and automatic control devices for operation of forced air or other oil cooling equipment which will permit operation of transformers at higher-than-normal ratings.

f. Bushings

Check to see that bushings are free of moisture, dust, chips and cracks.

g. Insulating Liquid

Check against requirements. Nonflammable fluid insulated power transformers are generally required indoors.

h. Grounding

Check grounding connections of metal housing, neutrals of primary and secondary winding to the grounding system. (NEC 450-9).

i. Ventilation

See that ventilation is adequate. (NEC 450-45).

305-24 SWITCHGEAR (NEC 384)

Switchboard and Free-Standing Panel Installations - Check for:

a. Level floor location for gear and any roll-out equipment.

b. Anchor bolts and floor plates in proper location. Consult approved shop drawings and contract drawings.

c. Conduit entrances and wiring trenches in proper location.

d. Bus duct connection provisions suitable for duct attachment.

e. Ground bus connections brought to proper location. Consult approved shop drawings.

f. Plumb and level installation of gear.

g. Installation in accordance with manufacturer's instructions.

h. Blocking removed from instruments and relays.

i. Adjustments made where required, taps and plugs at proper settings. Consult manufacturer's installation instructions.

j. Fuses in place and of proper type - voltage, current, interrupting capacity - current limiting.

k. Indicating lamps with proper color caps in place.

l. Furnishing of spare fuses and lamps and any operating handles or cranks.

m. Manufacturer's instruction books, wiring diagrams, etc., delivered to responsible individual accepting installation. Make a list and have it signed and filed.

n. Nameplates with approved nomenclature.

o. Terminals marked in accordance with approved shop drawings and specifications.

p. All wiring connections made up tight.

q. If switchgear is to be installed in any hazardous locations, check the specifications and drawings for the required special construction features.

r. Check for sufficient clearance between back of switchboard and wall. Minimum of 18 inches required if equipment or wiring is accessible only from back. Additional clearance may be required.

s. Check to be sure switchboard frame is grounded.

t. Check to be sure conduit stub-ups have coupling installed at floor level if required by Project Specifications.

u. Check to be sure that proper phase relationship and identification of connections including instrumentation has been accomplished.

305-25. ENGINE GENERATOR SETS

a. See paragraph 308 f. for installation of sets.

b. Inspect for overall compliance with the specifications as to type and rating of components - kva, kw, horsepower, rpm, voltage - and in particular as to the following:

(1) Engine will be suitable for operation on the fuel specified.

(2) Voltage ratings of starter, battery, and battery charger will be the same. Voltage regulator may need to be reset if nickel cadmium batteries are furnished.

(3) Check spare parts provided with unit to see that the supply is complete and that they fit the unit furnished.

(4) Installation should be in accord with NFPA 30, 31, 37, as required by Project Specifications. Check for proper calibration of gage stick.

(5) That ventilation is adequate.

(6) See that operation and maintenance manuals are posted in engine room.

(7) Check operation of transfer switches.

(8) Check governor operation.

(9) Check cranking cycle for reset.

(10) Check to determine that emergency shut-down prevents recycling.

(11) Required field tests have been satisfactorily completed.

305-26. ELEVATOR INSTALLATION (NEC 620).

a. See paragraph 308 g. for installation features.

b. Check voltage rating of hoisting machinery.

c. Provide safety interlocks as specified and check operation.

305-27. MISCELLANEOUS SYSTEMS (NEC 720, 725, 800, 810).

Include several types of audible and visual paging systems, nurses call, central dictation, intercommunication systems of the loudspeaker and telephone type, fire alarm systems, clock systems and supervisory systems, and often those which combine more than one function in a single system. Products of different manufacturers of like systems may differ greatly. Manufacturer's installation instructions will be rigidly adhered to. The following will apply to all systems generally:

a. Master sets and main or central station equipment and switchboards of miscellaneous systems will be so placed as to be easily accessible for operation and maintenance in locations having adequate ventilation.

b. Component parts of miscellaneous systems will be products of one manufacturer.

c. Wiring between system components may be of special character. Inspect for requirement for use of shielded cables, twisted pairs, and isolation of any system from another.

d. Check installation of miscellaneous systems equipment to see that proper sizes of fuses have been used, that leads are connected to proper terminals and that the equipment is designed to operate on the available supply voltage.

305-28. TESTS

a. All Testing

(1) When testing of any electrical equipment or systems is required, advise the electrical inspector or engineer and obtain his assistance. The following paragraphs cover a wide range of testing and it will be your responsibility to obtain assistance when such testing is beyond your capabilities or knowledge.

(2) Unless otherwise specified, testing should be performed by the contractor when the inspector is present. All arrangements for tests should be made by the contractor. For tests of major

equipment and high voltage cables, the contractor should also notify the manufacturers so they may witness the tests.

(3) The Using Agency should be notified when any unusual testing is to be performed so that they may be present to witness the test. Using Agency cooperation should be obtained well in advance for any tests which may affect their facilities or operations.

b. Precautions should be taken to insure that test voltages are applied only to equipment or circuits under test, and that all instrument and control circuits are disconnected during the test.

c. Electrical tests should not be conducted under ambient conditions unsuitable for testing, such as excessively high humidity conditions.

d. Records of tests should be complete, including ambient temperatures and weather conditions, circuit designation and extent of wiring systems tested, name and serial number of the machine tested, and signatures of those witnessing the tests.

e. Description of Tests

(1) De-energized operational testing will determine that moving parts do not bind, rotating parts work freely and are not obstructed by foreign materials, that they are lubricated as required, and that such limits or stops as may be necessary to restrict the motion of moving parts are in place and functioning.

(2) Operational testing will show that the equipment performs all functions for which it is designed in accordance with the design and manufacturer's specifications.

(3) Continuity testing will determine that circuits are continuous throughout the circuit.

(4) High potential testing will determine that the insulation has sufficient dielectric strength to withstand the surges to which it might be subjected and to insure freedom from pinholes and any other possible damage.

(5) Megger tests will determine that the wiring system and equipment is free from short circuits and grounds, and will measure the insulation resistances of the circuit and/or equipment under test.

f. Megger tests of insulation resistance should be made when specified and approved if satisfactory.

g. Method of Testing

(1) High-potential field tests should be made in strict compliance with the applicable standards listed in the specifications and the recommendations of the manufacturer of the equipment.

(a) Tests should not be repeated unless the necessity for repetition has been determined by your supervisor.

(b) Make certain that all safety precautions relative to grounding of the test equipment have been checked.

(2) Insulation resistance and high-potential tests of wiring systems should be made between one conductor and ground with all other conductors and sheath or conduit connected to the same ground. Tests should be made on each conductor in this manner. Windings of rotating equipment and transformers should be connected together and tested to ground.

(3) Leakage-current readings should be taken during all DC high potential tests.

A continual increase in leakage current during the test should be reported to your supervisor as a probable indication of faulty insulation.

(4) Rotating equipment operational tests should include an inspection for alignment with driven machine, proper lubrication, freedom from excessive vibration in operation, proper direction of rotation, voltage and current drain check against motor nameplate ratings, check of R.P.M. and excessive heating.

(5) Switch and manual motor starter operational tests should include an examination for proper operation, alignment of contacts and contact pressure.

(6) Motor-starter operational tests should include manually operating the armature or plunger and contact-bar to determine that movement is free, contacts are in alignment, contact pressure is adequate and that auxiliary contacts function properly. The starter should be energized from all control points and the operation of all control-circuit interlocks should be checked.

(7) Reduced voltage starters should be checked for correct sequence and timing

of application of incremental and full voltages.

(8) Variable and adjustable speed motor controls should be checked to see that operating speeds correspond to the position of the speed control device.

(9) Circuit-breaker operational tests for large air circuit-breakers should include, where applicable, three open-close-open cycles in both operating and test positions under manual operation and through control-circuits from each control point. Check breaker mechanisms for alignment; freedom of motion and adequate pressure of contacts; tripping devices; inspection to insure that breaker cannot be moved from operating position while closed. Indicating lights, targets, annunciators and alarms should be observed for operation in connection with associated circuit-breakers, control switches and other operating devices to insure that the signal indication corresponds to the switch position of the indicating device.

(10) Protective relays should be checked to see that time and current settings have been made as specified.

(11) Operational tests of relays should include: Checking of operation at specified current or voltage and time values. Checking of peak-current of instantaneous elements; checking of differential elements for operation only under condition of proper direction of power flow.

(12) Rod electrodes should be tested for resistance to ground. If resistance is greater than the specified resistance, or maximum of 25 ohms, additional rods or longer rods should be installed. Consult specifications (Project Specifications: NEC 250-83).

(13) Miscellaneous systems, for intercommunication, paging, clock-control fire alarms, etc., shall be given operational tests at all operating points to demonstrate that they will perform all specified functions. In particular, it shall be demonstrated that sounding devices are audible under normal ambient sound-level conditions in areas for which coverage is specified, that false signals cannot be transmitted over fire alarm systems specified to be of the noninterfering type, that reserve-power attachments for clock system will operate for the specified length of time, and that all special fea-

tures and accessories specified for each system have been incorporated therein.

(14) Engine-generator tests include, but may not be limited to, the following:

(a) If diesel engine driven, reference is usually made to Diesel Engine Manufacturers Association publication entitled, "Standard Practices for Stationary Diesel Engines". This publication details test requirements.

(b) Demonstrate starting of all units from all manual control points and from automatic control as specified.

(c) Demonstrate voltage and frequency regulation are held within specified limits under all load conditions.

(d) Establish load requirements for testing of units. Either connected load or created load such as obtained with salt water rheostat or other satisfactory method. Determine who will furnish load banks, if required.

(e) Engine-generator tests should incorporate full load tests. Specifications will at times require 110% load testing for a limited time.

(f) Satisfactory operation of transfer switch installation in accordance with specification requirements should be demonstrated.

(g) Operational check of all safety controls should be made. This will include operation of safety stop switches, operation of high water temp, low oil pressure, over-speed, and any other safety circuit required by the specifications.

(h) Demonstrate full load continuous operation without overheating of the engine.

CHAPTER 306
EXTERIOR ELECTRICAL
INDEX

Para.	Title	Page
306-01	GENERAL	306-1
306-02	AERIAL DISTRIBUTION	306-1
	a. Poles	306-1
	b. Crossarms	306-3
	c. Hardware	306-3
	d. Insulators	306-4
	e. Conductors (Aerial)	306-5
	f. Guying	306-6
	g. Transformers	306-8
	h. Primary and Secondary Fuse Cutouts	306-10
	i. Lightning Arrestors	306-11
	j. Pole Top Switches	306-11
	k. Grounding	306-12
	l. Street Lighting	306-13
	m. Underground Risers	306-14
306-03	UNDERGROUND DISTRIBUTION	306-15
	a. Duct System	306-15
	b. Manholes, Handholes and Underground Vaults	306-17
	c. Primary Cables	306-18
	d. Direct Burial Cable	306-20
	e. Potheads	306-21

Chapter 306

Para.	Title	Page
f.	Transformers in Fenced Inclosures	306-22

CHAPTER 306
EXTERIOR ELECTRICAL

306-01. GENERAL

This chapter covers exterior electrical distribution systems, aerial and underground, and transformer stations.

Preliminary inspection of materials prior to installation for conformance with specifications, plans, approved shop drawings, and lists of approved materials is essential. Components for distribution systems should be inspected before they are installed and energized.

306-02. AERIAL DISTRIBUTION

a. Poles

(1) Check class, length, condition, and treatment of poles against design requirements. (A current edition of ASA Standard 05.1, "Wood Poles," should be available to the inspector.) Be sure that certificate of compliance with applicable AWPA preservation specification has been submitted.

(2) Be sure that contractor's provisions for storage and handling of poles are in accordance with specification requirements.

(3) Usually, specifications require poles to be full treated rather than butt treated. The preservation specification should be checked for verification.

(4) Poles should be turned, chamferred, trimmed, roofed, gained, and bored prior to pressure treatment. When field boring or gaining is necessary, additional preservative should be applied to bared surfaces.

(5) Examine type of handling tools.

(6) Be sure that gains have been made for all cross-arms.

(7) A site check of the pole line route and pole locations should be made to be sure that pole lengths furnished will be suitable to carry all intended circuits (including communications) and still maintain required vertical and horizontal clearances from the ground and other obstructions. (A current edition of The National Bureau of Standards Handbook H30, National Electrical Safety Code, should be available to the inspector.)

(8) Be sure that the depths of pole holes are equal to minimum specification requirements, and that the width of each hole is adequate for backfilling and tamping in 6-inch lifts when required by the

specifications. Surplus earth should be piled around the pole and tightly tamped to assist in drainage away from the pole and to compensate for shrinkage of the backfill.

(9) If design requires numbering of poles, see that this is done correctly.

(10) See that the grading of pole tops is even.

(11) When it is necessary to shorten a pole, see that the cut is made at the top and that it is treated with hot preservative.

b. Crossarms

(1) Check material and preservative treatment.

(2) Examine fastening.

(a) Inspect installation, bolting, setting angle, number, type and length of crossarm and secureness obtained.

(b) Check vertical spacing of multiple crossarms.

(c) Check pin hole spacing.

c. Hardware

(1) Be sure that all ferrous hardware (braces, bolts, clamps, pins, nuts, washers, screws, etc.) is standard pole line galvanized hardware.

(2) Be sure that all hardware is of the specified size and strength.

(3) Be sure crossarm pins are of the specified strength and height.

(4) Bolts should not protrude more than approximately 2 inches or less than 1/8 inch beyond the nut.

d. Insulators

(1) Check furnished insulators against specification requirements.

(2) Inspect for damage.

(a) Reject chipped or cracked insulators.

(b) See that color coding is provided on street lighting and neutral conductors if required by specification.

(3) Check types and spacing of pins.

(4) Determine location of guy insulators.

e. Conductors (Aerial)

(1) Compare furnished supports with plans and specifications:

(a) Stranded or solid

(b) Copper, aluminum, or combinations of copper and steel or aluminum and steel

(c) Bare, weatherproof covered, or insulated conductors

(d) Size

(2) Check during installation:

(a) Tree trimming

(b) Sag of lines

(c) Handling (Watch for methods which will produce twists, kinks, abrasions, or cuts

(d) Method of dead ending

(e) Connectors and treatment of conductors at connectors or splices

(f) Armor rod and/or armor tapes on aluminum conductors at supports.

(g) Tie wires and methods of securing conductors to insulators

(h) Installations requiring racks and utilization of same

(i) Horizontal and vertical clearance between conductors (Handbook H30, H81)

(j) Installation and location of drip loops

(k) Connectors on service drops - If dissimilar metals are connected be sure that approved connector is used.

(l) Dead ending with approved clamps with strength not less than that of the conductor

(m) Areas requiring special protection

(n) Requirements for neutrals

f. Guying

(1) Compare the type of guy with its intended use.

(2) Check type and size of anchors against ground conditions.

(3) Check material to be used.

(a) Check for protective thimbles and thimble eye bolts.

(b) Examine three-bolt clamps at guy terminals.

(4) Check during installation:

(a) Anchor distance from poles (Anchor and guy strength is based on 1 to 1 slope. If the distance between pole and anchor rods has to be decreased, strengths must be increased).

(b) Location of guy insulator if required

(c) Point of attachment on pole

(d) Installation of rock anchors

(e) Location of expansion anchors and log anchor rods

(f) Need for additional guys

(g) Installation of guy protectors

(h) Gaining of poles for push braces

(i) Identification of primary phases stamped on all transition poles and at all substations entering and leaving

(j) Length of anchor rods

(k) Grounding and bonding of guys when specified

g. Transformers

(1) Check method of mounting:

(a) Determine capacity of transformer or banks of transformers.

(b) See if method of mounting is similar to adjacent connected system, and notify supervisor of deviation.

(2) Check materials:

(a) Conformance with NEMA Standards

(b) Primary and secondary voltage rating, kva capacity, and taps

(c) NEMA Standards for accessories of different capacity transformers, such as thermometers, liquid level indicators, liquid sampling devices, external tap changers

(d) Transformer hangers for rigid mounting on the crossarms

(e) Transformer bushings for rigid mounting with no evidence of cracks or chips

(f) Transformer tanks for pin hole leaks

(g) Impulse test certification if required by specification

(3) Check during installation:

(a) Correct tap setting

(b) Even distribution of weight of transformer banks

(c) Mounting, crossarms, braces, wiring on pole mounting of H frame mountings

(d) Primary and secondary connections

(e) Grounding of transformer tanks

(f) Rating of protective fuses

(g) Accessibility of fused cutouts on pole

(h) Type of electrical connections

(i) Fused cutouts and lightning arrestors installed on the primary side of each transformer supplied from an exterior distribution system.

h. Primary and Secondary Fuse Cutouts

(1) See that approved type is used. Is it indicating or dropout; enclosed or open?

(2) Check current and voltage rating and short circuit interrupting capacity against design requirements.

(3) Be sure fuse links are of the capacity and delay specified and that they do not exceed the capacity of connected conductors. (Capacity tables for bare and insulated wire may be found in NFPA Handbook 70, National Electrical Code, Tables 310-13 through 19).

(4) Check connection points of line conductors and load conductors.

(5) Examine type of bracket. Be sure bracket is secure, clear of adjoining structure, and convenient for operation.

i. Lighting Arrestors

Check:

(1) Location

(2) Voltage rating and type against specification requirements

(3) Mounting bracket

(4) Grounding connections

(5) Ground resistance prior to energizing the line

j. Pole Top Switches

(1) Check switches. Make sure that correct current and voltage rated ones are used.

(2) Assure that contact surfaces will operate under ice conditions.

(3) Watch arcing horns for contact during operation.

(4) See that operating rods are provided with an insulator in the rod if specified.

(5) Make sure operating handle is equipped with lock and keys. If inter-

locking keying is specified be sure it is furnished. Check out interlocking.

(6) Examine location of operating handle for convenience and safety.

k. Grounding

(1) Check type of ground conductors against design.

(2) Inspect exothermic welded ground connections for size rod, connector and powder charge against manufacturer's recommendations.

(3) Examine mechanical grounding connectors.

(4) Check connectors to aluminum conductors. Connectors must be approved for aluminum.

(5) See that grounding conductors are protected from mechanical injury.

(6) Determine and record ground resistance; also determine need for additional ground rods.

(7) Record driven depth of ground rods.

(8) Insure that all noncurrent

carrying metal parts on pole are grounded when specified.

(9) Check for separate grounding conductors and rods for lightning arrestor and equipment when required by specifications.

1. Street Lighting

(1) Examine all street lighting components.

(a) Check lighting bracket.

(b) In inspecting fixtures watch for:

1. Light diffusing pattern
2. Open or enclosed type
3. Gaskets to protect the globe
4. Film cutouts on series systems
5. Free access for maintenance
6. Insulating transformers

(c) Inspect regulator for kw rating, input voltage, and output current.

(d) Verify protector and control equipment voltage rating.

(2) Check during installation:

(a) Height of fixture

(b) Lightning arrestors and fused cutouts installed on each phase of the supply to the protector

(c) That all ferrous surfaces are hot dip galvanized

(d) That each fixture is secured with required number of through bolts of correct size

(e) All metallic poles or standards

m. Underground Risers

(1) Examine conduit clamps for size and number.

(2) Check duct seal at the conduit terminations. .

(3) Look for approved insulated bushings at the conduit termination.

(4) Check cable terminations.

(5) Inspect during installation:

(a) Lag screws used on the conduit clamps

(b) Cable supports to eliminate weight on the cable terminations

(c) Metallic conduit below grade has approved protective finish as required

(d) Stress cones on shielded cable

(e) Safe climbing space

306-03. UNDERGROUND DISTRIBUTION

a. Duct System

(1) Check:

(a) Materials

(b) Method of encasement

(c) Painting

(d) Duct supports and spacers for size to maintain duct spacing

(2) Check during installation:

(a) End bells and bushings at duct terminations

(b) Ground bushings at all conduit terminations

(c) Strength of concrete and presence of reinforcing steel where required under roads, paved area, etc.

(d) Compacted subgrade

(e) That spacers and spacing between ducts are covered with the minimum thickness of concrete on all sides of ductbank

(f) Spacing between electric and signal ducts

(g) Alignment and grade of conduits, especially during encasement with concrete

(h) Staggering of conduit joints

(i) Adapters for joining dissimilar types of duct (See that they are not field fabricated).

(j) Changes in direction made with factory fabricated devices

(k) Ducts secured in the forms

(l) Ducts pitched to drain

(m) Duct plugs used during construction and on all spare ducts

(n) Cleaning of ducts

(o) Seal duct entrances into manholes

(p) Cover over ducts

(q) Pull wires in place

(r) Minimum curve radius of duct line in accordance with specification

(s) Installation of marker if required by specifications

b. Manholes, Handholes and Underground Vaults

(1) Determine strength of concrete.

(2) Check quantity and size of reinforcing steel.

(3) Check strength of cover and frame, marking of cover, and machine finished joint between frame and cover.

(4) Be sure that approved cable racks, pulling irons, steps, ground rod, etc., are provided in the specified quantity.

(5) Check during installation:

(a) Sequence of concrete placement (Construction joints are undesirable between the base and walls.)

(b) Seal around duct entrances (and plug unused ducts)

(c) Pull irons are located opposite duct entrances

(d) Waterproofing

(e) Sump or drain

(f) Quantity and location of cable racks, hooks, and insulators

(g) Ground rod and ground cable

(h) Grounding of cable racks and lead cable sheaths

c. Primary Cables

(1) Inspect splicing kits and methods.

(2) Check qualification of cable splicer.

(3) Check cables for insulation, shielding, stranding, jacket or sheath and voltage rating.

(4) Examine potheads and pothead compounds.

(5) Check during installation:

(a) Type of pulling compounds (Grease or oil base compounds will deteriorate rubber coverings.)

(b) Setup of reels (Do not Kink).

(c) Cable sealed for pulling

(d) Abrasion to sheaths on manhole frames

(e) Even tension used in cable pulling

(f) Cable routing in manhole

(g) Splicing or terminating of cable

(h) Conductor identification tags

(i) Stress cones at splices and terminations

(j) Ground shielding at splices and potheads

(k) Abrasion or damage to cable by dragging on ground

(l) Fireproofing cables in manhole when specified

(m) Required tests

d. Direct Burial Cable

(1) Check protective covering or armor. Check manufacturer's designation for use. Compare material with approval data.

(2) Check during installation:

(a) Type of bedding and covering (should be smooth and free of stones and sharp objects)

(b) Use of untreated plank over cable when specified

(c) Method of laying

(d) Weaving of cable in trench

(e) Radius of bends

(f) Splices (minimization)

(g) Use of approved splicing kits

(h) Installation of concrete cable markers with letter and arrow

(i) Conduits with bushings under traffic crossings

(j) Spacing between cables

(k) Compaction over cables

e. Potheads

(1) Check size for the conductors or cables.

(2) Check stuffing box or wiping sleeve.

(3) Verify that compound is approved and installed as required.

(4) Make sure that installation is by a qualified splicer.

(5) Check stress cones.

(6) Test compound for correct pouring temperature.

f. Transformers in Fenced Enclosures

(1) See that ferrous materials are protected with galvanized finish or are painted.

(2) Insure transformers, potheads, fused cutouts and lightning arrestors conform with the electrical characteristics specified and/or approved.

(3) Check installation of primary and secondary cabling for stress cones, waterproof connections, and insulators.

(4) Check during installation:

(a) Swing of gates

(b) Drainage of transformer pad

(c) Elevation of transformer off-pad

(d) Grounding of all noncurrent carrying metal within the enclosure

(e) Grounding of the fence and gate enclosure

(g) Bonding of all metal conduits

terminating in the transformer enclosure to the grounding system.

(h) Proper warning signs affixed to enclosure fence

(i) Welds on fence structure are protected in accordance with specifications

CHAPTER 307
CATHODIC PROTECTION
INDEX

Para.	Title	Page
307-01	GENERAL	307-1
307-02	SHOP DRAWINGS	307-2
307-03	ANODES	307-2
307-04	CONDUCTORS	307-3
307-05	CONDUCTOR CONNECTIONS	307-3
307-06	INSULATING JOINTS	307-3
307-07	BONDING	307-3
307-08	TEST POINTS	307-4
307-09	FOREIGN PIPES AND STRUCTURES	307-4
307-10	BACKFILL FOR UNDERGROUND STRUCTURES	307-4
307-11	AUXILIARY EQUIPMENT	307-4
307-12	ELECTRICAL MEASUREMENTS	307-5
	a. Impressed Current System	307-5

Chapter 307

Para.	Title	Page
b.	Sacrificial Type Anode System (using Metallic Anodes without external power supply)	307-5
c.	Starting and Adjusting	307-5
d.	Recording	307-5

CHAPTER 307
CATHODIC PROTECTION

307-01. GENERAL

a. Cathodic protection is provided to preserve underground or underwater metallic structures including submerged interior surfaces of water storage tanks from corrosion. Corrosion takes place at points where electric current leaves the metal and travels through ground or electrolyte to another metal or to a different place on the same pipe or structure. Corrosion is arrested when an electromotive force is impressed on an underground or underwater metallic structure in such a way as to make the entire structure cathodic with respect to the adjacent soil or water.

b. Cathodic protection can be provided as described above or in the following manner: Sacrificial galvanic anodes are used having a difference of potential with respect to the structure to be protected. The anodes are made of a material, such as magnesium or zinc, which is anodic with respect to the protected structure. The galvanic-anode system is designed to deliver relatively small currents from a large number of anodes.

307-02. SHOP DRAWINGS

a. The following items, if required in the work, must be approved prior to installation:

Anodes
Conductors
Rectifiers
Conduit
Electrical boxes
Splicing materials
Anode hangers for tanks
Transformers

b. Check material brought to the job site against the approved shop drawings.

307-03. ANODES

a. Be sure the anodes are not broken while being installed. (Some anodes, such as duriron, are very brittle.)

b. Do not vary the spacing of the anodes more than 5% either way.

c. The location of the anode bed should not be changed without consulting your supervisor.

d. Be sure anodes are installed in accordance with design and specification.

307-04. CONDUCTORS

The insulation on the conductors must not be damaged during construction on impressed current systems. If it is damaged, the conductor may soon be destroyed by electrolytic action.

307-05. CONDUCTOR CONNECTIONS

Assure that joints are mechanically and electrically secure and that they are watertight.

307-06. INSULATING JOINTS

Determine if insulating joints in pipe structures are required. Install in accordance with construction drawings. The insulating joints are used to accomplish the following: (1) Isolate dissimilar mettals; (2) Sectionalize pipe lines with dissimilar coatings;(3) Sectionalize one cathodic protection system from another.

307-07. BONDING

a. See that pipe joints are bonded (if called for in the contract) before the pipe line is backfilled.

b. Be sure that bonds to other piping systems or structures are installed. If they are the resister type, see that they are adjusted.

307-08. TEST POINTS

Test points must be located exactly as shown on contract drawings.

307-09. FOREIGN PIPES AND STRUCTURES

a. Foreign pipes and structures may require cathodic protection.

b. If you should discover, in the vicinity of the cathodic protection system, underground metal pipes or tanks that were unkown to the designer, bring them to your supervisor's attention.

307-10. BACKFILL FOR UNDERGROUND METALLIC STRUCTURES

a. Backfill of pipes and tanks must not contain rock or materials which would damage the coating on the structure or pipe.

b. Check to see that only specified types of backfill are used. Cinder backfill should never be used.

307-11. AUXILIARY EQUIPMENT

Check the installation of the rectifiers, transformers, conduit and other electrical equipment using applicable parts of Chapter 306 of this Guide.

307-12. ELECTRICAL MEASUREMENTS

a. Impressed Current System

Inform your supervisor when the installation is complete.

b. Sacrificial type anode system (Using Metallic Anodes without External Power Supply)

Inform your supervisor when the system is complete, prior to bonding the anodes to the structure.

c. Starting and Adjusting

Do not start the system to make adjustments. Your supervisor will obtain the services of one qualified in cathodic protection systems to perform these fuctions.

d. Recording

Obtain a copy of the readings taken by the cathodic protection expert, including the potential measurements of the pipe before and after protection is applied, rectifier current and voltage readings for each set of potential measurements after the system is connected. These readings should be kept in the job records and turned over to the Using Agency when the work has been completed.

CHAPTER 308
INSTALLATION OF EQUIPMENT
INDEX

Para.	Title	Page
308-01	GENERAL	308-1
	a. Scope	308-1
	b. Scheduling and Delivery	308-1
	c. Approval of Equipment	308-2
	d. Layout	308-2
308-02	GENERAL INSPECTION OF EQUIPMENT INSTALLATION	308-2
	a. Foundations	308-2
	b. Grouting	308-3
	c. Alignments	308-4
	d. Flexible Couplings	308-4
	e. Vibration Isolators	308-5
	f. Marking of Equipment	308-5
	g. Electrical Work	308-5
	h. Welding	308-5
	i. Lubrication	308-5
	j. Operation and Testing	308-6
308-03	GENERAL INSPECTION OF EQUIPMENT	308-6
308-04	SPECIFIC EQUIPMENT	308-13

Chapter 308

Para.		Title	Page
308-04	a.	Pumps (Excluding Water Pumps)	308-13
	b.	Sewage Treatment	308-21
	c.	Water Distribution	308-30
	d.	Generating Units	308-34
	e.	Elevators	308-38
	f.	Cranes and Hoists	308-41
	g.	Incinerators	308-42

CHAPTER 308
INSTALLATION OF EQUIPMENT

308-01 GENERAL

a. Scope

This chapter covers the installation of the most common types of the various electrical and mechanical equipment installed on construction projects. There are equipment types which are not covered in this chapter, but the check list items included herein will assist the inspector in recognizing equipment deficiencies regardless of type.

b. Scheduling and Delivery

(1) Determine that shop drawings and data on each piece of equipment will be submitted in time to obtain approval, and avoid delaying the contract.

(2) Make sure that delivery of equipment is scheduled so that the equipment may be hauled from the point of delivery and set in place; and that if premature shipment is made, adequate storage facilities are provided.

(3) Coordinate between the shipment of equipment and the progress of construction to avoid delaying or tearing out construction to get equipment into the building. Also determine that access to the building and to the location where the equipment will be installed will be available when equipment is delivered.

(4) Check other construction for elimination of possible conflicts, i.e., floors drains, underground utilities, etc.

c. Approval of Equipment

As soon as equipment arrives on the job, check it against each detail and requirement on the approved shop drawing. Anything that is not understood should be reviewed with the supervisor.

d. Layout

Determine at an early stage of construction that the equipment will fit into the available space. If there is any question, obtain a layout drawing from the contractor.

308-02. GENERAL INSPECTION OF EQUIPMENT INSTALLATION

a. Foundations

(1) Correlate location with approved shop drawings.

(2) Determine width and length.

(3) Note the isolation of foundation base.

(4) Verify equipment clearances.

(5) Anchor Bolts

(a) Check layout and details of installation.

(b) Check anchor-bolt location with template and install pipe-sleeves to provide means of lateral adjustment and threaded extension beyond concrete.

(c) Plug or cap sleeves prior to placing concrete for foundations.

(d) Note for protection of anchor bolts. Grease if necessary.

(6) Inspect surface finishes, true plane surfaces, or step construction as required.

b. Grouting; Check:

(1) The use of non-shrinking grout.

(2) The filling of all voids.

(3) The use of steel shims.

(4) Grouting after equipment is aligned and bolts pulled down snug.

(5) If leveling screws have been released after grout has set and before tightening anchor bolts.

c. Alignment; Check:

(1) Alignment at time of installation.

(2) Permissible tolerances.

(3) Alignment before and after operation.

(4) Dowelling of equipment subject to dismantling.

(5) External connections to equipment to see that they are self supporting.

d. Flexible Couplings; Check:

(1) Installation.

(2) Alignment.

(3) Clearances.

(4) For application of necessary oil or grease.

e. Vibration Isolators; Check:

(1) The use of flexible connections.

(2) Manufacturer's data for details of installation and permissible loading.

f. Marking of Equipment

Verify that manufacturer's nameplates, equipment serial numbers, or code stamps are not covered or hidden from view by paint or insulation.

g. Electrical Work

(Refer to Chapter 305)

h. Welding

(Refer to Chapter 203)

i. Lubrication

(1) Prior to operation, assure that tanks are filled and manufacturer's lubrication instructions are followed.

(2) Check the type of lubricant.

(3) **Recheck** oil sumps after operation.

j. Operation and Testing

(1) See that all required tests are performed as specified.

(2) Assure that the contractor performs the tests under the supervision of the manufacturer's representative, if required.

(3) Make sure all test results are recorded and that a copy is obtained.

308-03. GENERAL INSPECTION OF EQUIPMENT

a. Look for physical damages caused by handling or shipping.

b. Verify compliance with approved shop drawings.

c. Inspect materials of construction.

d. Verify capacities and ratings.

e. Assure the presence of guarding devices for all moving parts.

f. Determine that electrical grounding is provided for specified equipment, and test to assure the same.

g. See that operation, maintenance, and installation instructions are furnished.

h. Determine lubrication requirements and check same.

308-04. SPECIFIC EQUIPMENT

a. Pumps (Excluding Water Pumps)

(1) General

(a) Determine that certified test curves are furnished for each type of pump.

(b) See that operation, maintenance and installation instructions are furnished.

(c) Note type of bearings.

(d) Check type of seal.

(e) Determine lubrication requirements.

(f) Determine water cooling requirements.

(g) Verify adjustment of stuffing-box glands and leakage of seals.

(h) Observe the direction of rotation.

(i) Examine guard device over couplings.

(j) Note electric motor drivers under operation.

(2) Positive Displacement Pump

Check by-pass or leak-off protection, in the event of a closed discharge.

(3) Centrifugal Pump; Check:

(a) Type of casing and material.

(b) Inherent self-priming features.

(c) Vent facilities on top of casings

(4) Deep Well Turbine Type Pump

(a) Obtain and record the impeller clearance settings as made by the pump manufacturer's service engineer.

(b) Check pumps for nonreversing ratchet or restrictor.

(c) Verify overhead clearance and openings in slab above for removal of pumps.

(d) Insure minimum submergence setting.

(e) See that vents are installed at the high point of all pumps.

(f) Note bowl serial numbers to assure correct assembly when field assembled.

(g) Inspect bowl alignment.

(h) Examine the check-valves installed between gate-valve and pump.

(i) Determine that pump setting is level and plumb.

b. Sewage Treatment Plants

(1) Sewage Bar Screens and Shredder

(a) See that bars are parallel to one another, equally spaced, and in the same plane of travel as the rakes.

(b) Observe the adjustment of teeth on rakes for proper mating with bar screen along entire travel. Reject rakes with damaged teeth.

(c) Determine that manufacturer's representative adjusts tension of sprocket chains.

(d) Notice rake wiper for efficient cleaning of rakes.

(e) Examine shock abosrber for elimination of excessive wiper shock and for smooth operation.

(f) See that complete assembly is set in concrete so that no water is by-passed between concrete and equipment.

(g) Require contractor to furnish competent engineer to instruct government representative in operation and maintenance.

(h) Witness operational tests for equipment performance required by specification.

(i) Obtain special tools, if required

(2) Grit Chamber; Check:

(a) Elevation and level of proportional weir.

(b) Rake travel to see that it is parallel with floor of chamber.

(c) Rake clearance for agreement with approved shop drawings.

(d) Sprocket chain tension and adjusting mechanism.

(e) Conduct operational tests as required.

(3) Settling Chambers (Sedimentation Tanks)

(a) Rectangular and Circular

1. Assure that all embedded items are installed and are properly located

2. Examine elevations of concrete baffles and scum troughs.

3. Observe and record all recommendations and settings made by manufacturer's representative supervising installation of equipment.

4. Evaluate adjustable weirs for elevation, level and range of travel.

5. Note adjusting mechanism of chain drive for easy operation and for sufficient range to procure proper tension in chain.

6. Inspect scum pipes for level and elevation.

7. Require lubrication with recommended lubricants prior to initial start-up.

8. View sprocket-shell bearings for cleanliness, freedom from binding, and smoothness of bearing surface.

9. Check sprocket teeth for defects and for meshing accurately with chain.

10. See that shafting is level, plumb, and free from rotation.

11. Check chain for damaged links.

(b) Rectangular

1. Examine skimming run support for level.

2. See that angle track is level and aligned with forward sprocket.

(c) Circular

1. Observe whether top of tank is level.

2. Inspect skimmer arm, blade, and receptacle for rigid support and assembly. Verify blade clearance.

(4) Dosing Chambers

(a) Check weirs for proper elevation and level.

(b) Check all siphon placement dimensions and position.

(c) Observe adjustment and operation of weir plates or stop planks.

(d) Verify location of trap open-vent pipe so that sewage does not discharge directly into it.

(e) Observe setting of bell with respect to top of main trap pipe.

(f) Assure that invert of vent and overflow pipe is above the maximum discharge level of the siphon.

(g) During preliminary testing of tank, check maximum and minimum discharge levels and the level at which the siphon stops operating (minimum drawdown level).

(h) Conduct operating tests as required.

(i) Contractor must furnish competent engineer, or superintendent, as necessary to provide proper installation and adjustments, to conduct tests, and to instruct government representatives in proper operation.

(5) Trickling Filter; Check:

(a) Filter media for size.

(b) That media material is protected from contaminants if stockpiled prior to placement in filter.

(c) For rejection of filter media that has been contaminated with nonremovable material such as oils, grease, soil, etc.

(d) Placing of filter material.

(e) Against contamination after finished placement of filter media.

(f) Underdrains, for uniform bearing over the entire bottom of each block. See that cross joints are staggered in adjacent rows.

(g) Air duct for blockages.

(h) That blocks in drainage channel are not moved by placement of filter media.

(6) Distributors

(a) Fixed Nozzle

1. Check stability and calking in joint of piping laid within filter.

2. Note spray nozzles for effective and uniform distribution of sewage over entire filter bed.

3. Assure furnishing of spare nozzles.

4. Perform operating tests as required.

(b) Rotary

1. Assure uniform distribution of sewage over entire filter bed.

2. Examine distributor arm flushing valve for tightness and freedom of operation.

3. Replace nozzles that do not show uniform flow characteristics.

4. Assure that distributor arms are level guyed.

5. Inspect seal for operation and for tightness.

6. Witness operation of arms at minimum heads for starting and for operation. Complete cycle through all heads to maximum.

7. See that motion of arms is parallel to surface of media.

(7) Sludge Digester

(a) Observe all embedded items for proper location.

(b) Evaluate all cover seals for gas tightness.

(c) Note overall inside diameter of tank of floating cover digesters for roundness and clearances.

(d) Examine cover rollers for clean bearings, ease of greasing operation, and alignment of rollers and guides.

(e) Inspect heating system piping for tightness, materials, and secure fastening.

(f) Assure that elevation of all cover rests are the same on floating cover digesters.

(g) Check sludge draw-off piping for location and rigid support.

(h) See that all heating system lines, gas lines, feed pipes, and supernatant lines are flushed prior to operation.

(i) Assure that all debris is cleaned from interior of structure.

(j) Check center post installation for plumbness and rigidity.

(k) Examine sludge mixer and scum breaker for operating ease and settings.

(l) Witness and record tests and adjustments made by manufacturer's representatives.

(m) Refer to Chapter 203 for Welding.

(n) See that all manholes and openings through cover are gas-tight.

(o) Note all sensing locations for thermometers and controls.

(p) Verify that speed of mixer is set by manufacturer's representative or contractor.

(q) Watch setting of gas pressure regulating valve.

(r) Check the use of flexible hose with double unions, in cold water connection to heating system.

(s) Obtain any special tools required.

(t) Perform operating tests as required.

(u) Require contractor to furnish competent engineer for instructional purposes.

c. Water Distribution

(1) Pumps

(a) Be familiar with all pumps manufacturer's recommendations, with Hydraulic Institute's standards, and see that installation is in accord with same.

(b) Determine that adequate foundation is provided.

(c) Verify the use of a direct drive pump when such is specified.

(d) See that pump can be dismantled without disturbing pipe connections or the alignment of pump.

(e) Assure that bronze parts are where specified.

(f) Check freedom of movement of impeller and shaft.

(g) Assure that water-seal is provided with proper type and size of packing.

(h) Inspect for necessary air cocks, drain plugs, gages, and relief valves.

(i) Determine whether gasoline engine is required and check out same. (Use check list for Generator Units, included in this chapter.)

(j) Check controls to see that they function as specified.

(k) See that all gears, couplings, projecting set screws, keys, and other rotating or reciprocating parts are fully enclosed or properly guarded.

(l) Make sure that instruction book, tools, and pump characteristic curves have been obtained from contractor.

(m) Examine Hydraulic Institute's standards and NFPA Standard No. 20 or American Standard B 58.1. See that tests are made in accordance with their requirements.

(2) Water Tanks and Stand Pipes

(a) Check foundation construction against plans, specifications, and shop drawings, and be sure to compare approved shop drawings for foundation with fabricated column base plates.

(b) Closely compare steel erection with approved shop drawings.

(c) Check the erection of steel, using Chapter 202 and Chapter 203 as reference.

(d) Examine the layout of valve

chamber to see that there is adequate room for later maintenance of all parts.

(e) Make sure all required checks, gates, altitude valves, and pressure gages are installed.

(f) Affirm that the results of the hydrostatic test are satisfactory.

(g) Check the installation of such items as cathodic lightning protection.

(h) Determine whether there is a complete shop coat coverage and that the tank receives the specified finish paint.

d. Generating Units

(1) See that contractor has verified all dimensions.

(2) See 301-02, b, c, and d for checking piping and fittings, and 305-25 for electrical features.

(3) Determine that skilled workmen are being employed.

(4) Assure easy access to all parts of the engine.

(5) Examine fuel handling and storage facilities.

(a) Observe tank installation.

(b) Check manhole construction; observe for watertight cover, and for the height of manhole cover.

(6) Assure necessary access doors in equipment.

(7) Check the water level.

(8) Check for excessive vibration.

(9) Observe adjustment of V belt drives.

(10) When operating the engine, check for excessive smoke, overheating, etc.

(11) Check day tank installation.

(a) Watch mounting and method of supporting.

(b) Determine that high level cutoff switch is properly installed.

(12) Make sure approved tanks are installed as specified.

(a) See that tanks are kept clean during installation.

(b) Check cleaning operation and its results.

(c) Examine priming and painting applications.

(d) Holiday test the tanks as necessary to assure a complete prime and paint job.

(e) Check voltage of holiday detector.

(f) Continually watch for abrasions.

(g) Carefully watch backfill operation, checking compaction and watching for any possible damage to tank or piping.

(h) See that all bare places on exterior of tank are repaired with hot enamel.

(i) Check cleaning of interior surface.

(13) Check the installation, anchorage, and support of all piping. This includes the exhaust piping and muffler.

(14) Make sure that all pipes, valves, fittings, pumps, etc., for the fuel and

lubricant systems are shipped to the job with ends closed. Check when installed to assure cleanliness, and continue to guard against the entrance of dirt and foreign matter into the equipment.

(15) Examine the acid cleaning, the neutralization, and the drying of the interior of the fuel piping systems.

(16) Note the requirement for expansion joints; Check:

(a) Type furnished.

(b) Method of installation.

(c) Misalignments.

(d) Follow manufacturer's instructions to determine range of movement for installing expansion joints.

(17) Mufflers; Check:

(a) Type

(b) Method of mounting.

(c) Treatment for rust resistance.

(d) Noise level.

(e) Drain hole.

(18) Be alert for the requirements concerning auxiliary equipment such as silencers, special controls, trickle chargers, filters, instrument boards, static exciters, voltage regulators, auxiliary compartments, and special tools.

(19) See that the required tests are made. Check:

(a) Safety circuit.

(b) Governor.

(c) Fly Wheel.

(d) Accessibility of brush rigging.

(e) Performance.

(f) Controls and interlocks.

e. Elevators

(1) See paragraph 305-26 for electrical features.

(2) See that equipment manufacturer's name plate is in a conspicous location.

(3) See that the contractor has checked equipment dimensions against the space available.

(4) Compare the features of the delivered equipment with the approved shop drawings.

(5) Check for accessories that can be provided with elevators, and which are often specified; such as fan, telephone provisions, light fixtures, convenience outlets, wrenches, direction-light jewels, etc.

(6) Verify that ferrous metal meets salt-spray fog test.

(7) Make sure that protection guards are provided for moving parts.

(8) Check contract installation requirements against the manufacturer's recommendations. Call your supervisor's attention to any differences.

(9) Check anchor bolts and conduits for proper location.

(10) Check elevator mechanics' and welders' qualifications.

(11) Carefully check all installations for stability, specified connections, anchorage, etc.

(12) Determine the type of lubrication required, and examine equipment for same.

(13) See that spare parts data is provided for each item of equipment.

(14) Operate the elevator to determine responsiveness.

(15) Check out all safety features.

(16) Installation of hoisting machinery may require that construction of certain floor and/or wall areas be deferred until installation is completed.

(17) Guard open shaftways until doors are provided.

(18) Guide rail installation will be rigidly supported and plumb.

(19) Inspect hoisting cables after installation for possible damage during the construction operation.

(20) Inspect spare parts and operation

gear for completeness and application to the installation.

(21) Assure that required tests are performed and that all data is recorded.

(22) Check to see that rigid tests have been accomplished to proved conformance with all specified safety standards.

f. Cranes and Hoists

(1) Compare the capacity of equipment with requirements.

(2) Check track for:

(a) Size of members.

(b) Method of supporting and anchoring.

(c) Stability and minimum sway.

(d) Being level and parallel.

(e) End-of-track stops or bumpers.

(f) The way wheels ride on track.

(3) Confirm that clearances are provided for required operation.

(4) Check ease of operation of equipment.

(5) Determine if all the various specified speeds can be obtained.

(6) Check if all safety devices such as limit switches, brakes, etc., have been furnished, connected and function as designed.

(7) See that specified tests are performed and recorded.

(8) Check welding and connecting of members.

g. Incinerators

(1) Make sure that the construction is in exact accordance with approved shop drawings. Check dimensions very carefully.

(2) Check construction and thickness of firebrick in furnace and flue connections. Watch for:

(a) Width of joints.

(b) Wall thickness.

(c) Handle of arches and circular linings.

(d) Size of baffle.

(e) Brick laid on edge in hearths and floors.

(f) Installation of expansion joints.

(g) Bracing.

(3) Check casting and bonding of refractory casting when same is used.

(4) See that insulating brick is installed in specified location.

(5) See Chapter 204 for installation of exterior wall brick.

(6) Assure that there is at least a 2" separation between exterior walls and fire brick lining of chimney.

(7) Check chimney for:

(a) Cleanout door and frame.

(b) Concrete protective cap.

(c) Spark screen.

(8) Assure the installation of a

safety rail around charging throats and quillotine.

(9) Check for the installation of such items as:

- (a) Dampers.
- (b) Auxiliary burners.
- (c) Test pipes.
- (d) Instruments.

(10) Determine if other equipment such as can-washing of forced-draft is specified and check same.

(11) Require that all necessary operating tools have been furnished.

(12) See that the unit is dried out in accordance with requirements.

(13) Assure that operating tests are conducted and that results have been recorded.

CHAPTER 401
PILE CONSTRUCTION
INDEX

Para.	Title	Page
401-01	GENERAL	401-1
401-02	GENERAL REQUIREMENTS	401-1
401-03	TESTS AND RECORDS	401-9
	a. Tests	401-9
	b. Records	401-9
401-04	INSPECTION	401-10
	a. Steel Pile - H Piles, Pipe Piles, Sheet Piling	401-10
	b. Timber Pile (Round)	401-12
	c. Timber Pile (Sheet)	401-15
	d. Concrete Sheet Piling	401-15
	e. Precast Concrete Piling	401-16
	f. Cast-In-Place Concrete Piles	401-18
401-05	INSTALLATION	401-19
	a. General	401-19
	b. Concrete Pile	401-20
	c. Driving for Resistance	401-20
	d. Overdriving	401-21
	e. Tolerances	401-22

CHAPTER 401
PILE CONSTRUCTION

401-01. GENERAL

Information contained in this chapter applies in general to pile driving on any project; specific information pertaining to a particular project should be obtained from your supervisor and from the plans and specifications. If a conflict exists between this chapter and the contract plans and specifications, the contract will govern.

401-02. GENERAL REQUIREMENTS

a. Check use of pile, i.e., point bearing or friction.

b. Check whether piles are to be driven to refusal, a specified bearing or depth.

c. Check workmanship, materials, and line and grade of completed work.

d. Maintain all required records.

e. Reject unsatisfactory materials.

f. Check testing of materials.

(1) At source of supply

(2) On site

g. Checks Prior to Driving

(1) Check pile lengths required and bearing capacity of piles.

(2) Check borings to determine the driving resistances to be expected and types of material to be encountered.

(3) Check piles as delivered to site and mark piles which are not acceptable.

(4) Check piles for length and have lengths indicated on piles near top.

(5) Check piles made up for specific locations; have the pile location number painted on the pile.

(6) Check out pile driving equipment for size and condition. Check boiler inspection certificate and other safety requirements where steam or compressed air is used. Continue checking daily.

(7) Obtain and study the brochure printed by the pile hammer manufacturer

pertaining to its use in order to become familiar with its capabilities and limitations.

(8) Check types of special piles and obtain the brochures or pamphlets put out by the manufacturers of these piles to become familiar with the methods of handling, inspecting and driving.

(9) Check for pile numbering plan. Enter in your report the order in which they are driven.

(10) Check that heads are flat and smooth and are normal to the longitudinal axis.

h. Checks During Driving

(1) Check and record care in handling piles, overdriving, hitting obstructions, driving out of plumb, retardation of stroke and sequence of driving.

(2) Check and record strata into which piles are driven and depths. Check against profile of borings.

(3) Check that records include type of pile, length used, type and size of hammer, manufacturer, strokes per minute,

blows per foot, number of blows per inch of penetration, elevations of pile butt and tip after driving.

(4) Check that approval is obtained for relocation of piles or driving additional piles.

(5) Check the behavior of the pile during driving.

(a) Check hardness of driving at various depths against the strata shown on the boring log.

(b) Check for deviations which indicate broken piles, obstructions or driving irregularities.

(6) Check steel driving shoes used on wood or concrete piles. Check damage to pile tip by pulling an occasional pile.

(7) Check that piles are driven continuously. If driving is suspended, note the tip grade at the time of the shutdown and the duration of the delay.

(8) Check uplift on piles.

(a) Check when piles are driven in

groups or clusters for heaving of earth around the piles.

(b) Check grades on piles after they are driven and later rechecked.

(c) Check with your supervisor if heaving occurs.

(9) Check that use of small tips is avoided. Check damage to tips on wood piles by pulling an occasional pile.

(10) Check for preparation of pile schedule and lengths.

(a) Drive several piles adjacent to boring locations.

(b) Note blows per foot for each foot.

(c) Compare (b) with boring data.

(11) Check that piles are set vertically, or, if batter piles, on the axis which they are to follow. Check that the hammer is centered over the pile.

(12) Check use of templates or timber bracing for guiding piles when driving without leads.

(a) Check deviation from proper location. Cut off and abandon and drive new pile.

(b) Pull and redrive.

(13) Check jetting is used only with approval of supervisor.

(a) Check depth jetting permitted.

(b) Check for walking out of plumb and loosening of piles previously driven.

(c) Check piles are redriven after jetting in area is completed.

(d) Check possibility of damage to existing structures if jetting permitted.

(14) Check lagging is used only with prior approval.

(15) Check piles are not driven within 100 feet of concrete less than 7 days old.

(16) Check ownership and payment of pile cut-offs. Check if cut-off lengths are excessive.

(17) Check your records indicate pay lengths.

(18) Check deviations from pile schedule; notify your supervisor.

(19) Check pile driving is not started until approval is secured as to the type and weight of the hammer to be used.

i. Site Conditions, Inspection of Equipment

(1) Check for unfavorable conditions such as rock, ledge, boulders not indicated on drawings, excessive soft spots, crusts, old foundations disclosed during construction, and report to your supervisor.

(2) Check site conditions,including lines, grades, foundation preparation, all available boring information, right-of-way, roadways, streams or other waterways, terrain, and all driving conditions.

(3) Check equipment proposed for use by the contractor will produce the finished work of required standards within the scheduled time.

(a) Check size of hammer.

(b) Check type of driving hammer

bases, anvils and caps against type of piling.

(c) Check followers are used only with the approval of your supervisor.

(d) Check condition of hammer for wear, improper adjustment, poor lubrication, long hose lengths, leaks and drops in steam pressure.

(e) Check double-acting and differential-acting hammers are run at manufacturer's rated speeds.

j. Pile Driving Procedure

(1) Check with supervisor procedure to be followed.

(2) Check formula to be used as a guide in determining bearing capacity.

(3) Check minimum bearing value to be obtained if not stated.

(4) Check with supervisor for blows per inch (or fraction of an inch penetration) for the last ten blows to be obtained when driving to refusal.

401-03. TESTS AND RECORDS

a. Tests

(1) Check test piles to be driven and method of loading.

(2) Check time required between driving and testing.

(3) Check test pile operation and log all data.

b. Records - Check daily job records of pile driving operations are complete and contain the following information:

(1) Site

(a) Depth of water (if any). (Condition of bottom if pile driver is in water).

(b) Elevation of water surface, tidal and stream flow or current observations.

(c) Elevation of ground surface.

(d) Ground-water elevation.

(e) Character of surface soil.

(f) Effect of pile driving on elevation of soil surface.

(g) Weather - Temperature, precipitation, high winds.

(h) Ground surface - Depth of frost (if any), wet, muddy, or dry.

(2) Location of Pile

(a) Identification by reference number on plan approved for field use.

(b) Actual location as driven and length of pile driven.

(3) Driving Record

(a) Pile Data - type and length used.

(b) Hammer Data - type and size and manufacturer of hammer used.

(c) Driving Data - blows per inch penetration, and elevation of butt and tip after driving.

401-04. INSPECTION

a. Steel Pile - H Piles, Pipe Piles, Sheet Piling

(1) Check upon delivery grade and type of steel and mill certificates.

(2) Check diameter, weight and type.

(3) Check surface condition, condition of interlocks, condition of pile point and pile head reinforcing or shaping.

(4) Check bends or flange injuries in shipment or handling.

(5) Check for defective rivets or welds, and fit at splices.

(6) Check certification of welders.

(7) Check number of splices per pile.

(8) Check storage and handling methods.

(9) Check interlock dimensions for interchanges and placing of piles for location, spacing, direction and threading of interlock of sheet piles.

(10) Check driving operations do not rupture interlock.

(11) Check on enclosed sheet pile structures for accuracy of initial pile location and plumbness.

(12) Check last closure pile is driven free without jamming or causing damage of interlocks.

(13) Check splices are staggered, and allowable splices per pile.

(14) Check cutoff elevations and allowable tolerances.

(15) Check handling and pulling holes are provided.

(16) Check expansion and contraction allowances on walers.

(17) Check caps are not placed before sway bracing, welding, etc. is completed.

(18) Check concrete is not dumped in pipe piles through water.

(19) Check sheet piling is left slightly higher than cutoff elevation.

(20) Check every tenth sheet pile is pinned to prevent walking and to maintain plumbness.

(21) Check that steel pile tops frayed or battered during driving are cut off.

b. Timber Pile (Round)

(1) Check type of timber as delivered.

(2) Check dimensions and straightness of the pile.

(3) Check for decay, knots, splits, shakes, crooks and bends.

(4) Check preparation of points and heads for driving.

(5) Check method and amount of treatment required.

(6) Check removal of bark.

(7) Check treated timber piling is not handled with cant dogs, spike poles, or hooks.

(8) Check all cuts and breaks are treated.

(9) Check use of collars or bands.

(10) Check the head of a timber pile is recut, if broomed.

(11) Check that driving of piles beyond the point of refusal is not permitted.

(12) Check cutoffs for all structures.

(13) Check bolt holes.

(a) Check holes bored for drift bolts are 1/16-inch smaller in diameter than the drift bolt.

(b) Check holes in treated piles and timbers are filled with hot creosote and where not used tightly closed by a treated plug.

(c) Check that holes are not bored or spikes driven in treated piles to support scaffolding.

(14) Check treated piles are cut off only during favorable weather.

(15) Check cutting of treated spreaders, walers and piles is not done to permit fitting, unless approved.

(16) Check ends of bolts and tie rods extending more than 3 inches beyond the nut are cut off to that length. Ends of all bolts shall be bent or battered after the nut is tight.

(17) Check bolts and tie rods have at least 3 inches of threads remaining under the nut after tightening the nut.

(18) Check walers for overlap, each

on each, and that proper number of piling is included in the overlap.

(19) Check washers for make, weight, shape and size.

c. Timber Pile (Sheet)

(1) Check on-site fabrication (Wakefield) for surfacing, grade and size of lumber; size and length of nails, spikes or bolts; proper dimensioning of fabricated work (tongue-and-groove dimensions); required nailing or fastening procedures.

(2) Check used Wakefield piling for tongue-and-groove dimensions, suitability of piling and proper lengths.

(3) Check painting of piles.

(4) Check nailing of driven piles is such as to prevent springing.

(5) Check liners and caps installation.

d. Concrete Sheet Piling

(1) Check tongue-and-groove interlocks are not chipped, cracked or broken.

(2) Check units are of uniform shape, true, and straight. Warped, bent or broken piles shall be rejected.

(3) Check interlocks are fully grouted, where watertightness is required.

e. Precast Concrete Piling

(1) Check quality of the concrete.

(a) Record concrete mix used.

(b) Check for conformance with approved mix.

(2) Check reinforcement is free from rust and scale and placed properly.

(3) Check casting yard operations for the following:

(a) Casting floor will be firm.

(b) Width of pallet boards.

(c) All cut ends of reinforcing tie wire are turned away from form surface.

(d) All inside surfaces of forms are smooth and clean.

(e) Chamfer strip (if required) is in place and firmly attached to form.

(f) Bracings and blocking between and around each piling firm.

(g) Check pile forms are level and straight with no openings.

(h) Check placing is continuous from start to completion, beginning at the head and working toward point.

(i) Check top surface is screeded and brushed to a uniform, even texture similar to that produced by the forms.

(j) Check upon completion of placement, each pile is stamped or marked on head and point to indicate date and length.

(k) Check as soon as practical that the lifting and stack points are painted on each pile.

(l) Check curing.

(m) Check handling of pile is not permitted until the required strength has been attained.

(n) Check lifting cables are provided with some device to equalize the pull at all lifting points.

f. Cast-In-Place Concrete Piles

(1) Check quality of the concrete.

(a) Record concrete mix used.

(b) Check for conformance with approved mix.

(2) Check reinforcement for cleanliness and placement.

(3) Check the prepared pile hole, before placing reinforcement, to check full dimensions and to see that no swelling or movement of the soil occurs before pouring concrete.

(4) Check identification of casings as delivered with those inspected and accepted at the manufacturer's plant.

(5) Check the driven casing for ruptures and plumbness before placing reinforcement or concrete, when the casing is to be left in the ground.

(6) Check that prepared pile hole is free of water before placing concrete.

(7) Check the elapsed time after placing concrete before placing the load on the pile.

401-05. INSTALLATION

a. General

(1) Check layout location for piles.

(2) Check template for sturdiness and elevation.

(3) Check pile hammer data before driving commences.

(4) Check boiler certificate is obtained from contractor if steam is used.

(5) Check handling of piles. Insist that pickup points be used.

(6) Check length and size of each pile for required location.

(7) Check penetration of pile immediately after setting and record in Daily Driving Log.

(8) Check alignment laterally, longitudinally and vertically; also batter lines (if battered piles are required).

(9) Check cushion condition beneath during actual driving operation.

(10) Check continuous driving until required depth or penetration is attained.

b. Concrete Pile

(1) Check that precast concrete piles are protected by means of driving heads.

(2) Check cast-in-place unit shells are thoroughly cleaned out with air or water jets and all water removed before concrete is placed.

(3) Check reinforcing steel is rigidly assembled, lowered into the shell, and adequately secured in proper position until concrete is placed. Loose bars shall not be permitted.

(4) Check provisions and method of cutting and splicing.

c. Driving for Resistance

(1) Check that the ram is operating at full stroke, rated speed, and under full recommended pressure.

(2) Check any evidence of slowing down of hammer.

(3) Check cushioning materials for conformance with those anticipated in the designer's resistance formulas.

(4) Check carefully the readings taken immediately after resumption of driving.

(5) Check inside piles are driven first, when piles are to be driven in groups.

d. Overdriving

(1) Check against overdriving when specific depths of penetration are unattainable due to some unforeseen condition underground.

(2) Check sound and character of vibration of the pile during driving for evidence of overdriving.

(3) Check bouncing of hammer or dissipation of the energy of the blow in bending or kinking of the pile as indications of overdriving.

(4) Check with supervisors the advisability of pulling an occasional pile to check for damage from overdriving.

e. **Tolerances**

(1) Check permissible tolerances are maintained.

(2) Check guides and templates are used to secure proper alignment until penetration is sufficient to determine its course.

(3) Check springing of piles during driving to bring them into proper alignment.

(4) Check tolerance in aligning and plumbing foundation piles which are to be buried.

(5) Check accuracy of line and plumbness for trestles, docks, small column footings and wall footings.

(6) Check piling is not trimmed or cut to facilitate the framing of sway or longitudinal bracing.

CHAPTER 402
LEVEE CONSTRUCTION AND EARTH EMBANKMENT CONSTRUCTION FOR DAMS
INDEX

Para.	Title	Page
402-01	GENERAL	402-1
402-02	GENERAL PROVISIONS	402-1
	a. Lines and Grades	402-1
	b. Conduct of the Work	402-2
	c. Records	402-3
402-03	CLEARING AND GRUBBING	402-3
402-04	STRIPPING	402-3
	a. Area Limits	402-3
	b. Use of Topsoil	402-3
	c. Stripping	402-3
	d. Drainage Provisions	402-4
402-05	FILL MATERIALS	402-4
	a. General	402-4
402-06	EXCAVATION	402-4
	a. General	402-4

Para. Title Page

b. Specific 402-5
c. Excavation Where Blasting is Employed 402-5

402-07 PREPARATION OF FOUNDATION 402-6

a. Bond 402-6
b. Fill 402-6
c. Loosen Foundation 402-6
d. Cleanup 402-6
e. Rock Foundation Preparation 402-7

402-08 PLACEMENT 402-7

a. Rolled Fill 402-8
b. Hydraulic Fill for Dams 402-10

402-09 MOISTURE CONTROL - ROLLED FILLED SECTIONS 402-11

a. General 402-11
b. Impervious Sections 402-11
c. Random Sections 402-12
d. Pervious Sections 402-12
e. Filter Drainage Layers 402-12
f. Rock Fill Sections 402-12

402-10 COMPACTION 402-12

Para.	Title	Page
	a. General	402-12
	b. Soil Types as Related to Compaction	402-12
	c. Methods of Compaction	402-13
	d. Types of Compacting Equipment	402-13
	e. Moisture Density Relationship	402-16
402-11	HYDRAULIC FILL FOR LEVEES	402-17
	a. Hydraulic Placement	402-17
	b. Outlets	402-17
	c. Damage	402-17
	d. Rehandling of Hydraulic	402-17
402-12	DRESSING	402-18
	a. Overbuilding of Embankment	402-18
	b. Final Grade	402-18
	c. Roughness of Surface	402-18
402-13	STONE PROTECTION	402-18
	a. Material	402-18
	b. Placement	402-18
	c. Gravel Surfacing	402-19

Para.	Title	Page
402-14	ZONING OF MATERIALS IN LEVEES	402-19
	a. Homogeneous Material	402-19
	b. Nonhomogeneous Material	402-19
402-15	GRADE TOLERANCES AND SHRINKAGE ALLOWANCE FOR LEVEES	402-20
	a. Tolerances	402-20
	b. Shrinkage Allowance	402-20
402-16	SETTLEMENT OF FOUNDATION OF LEVEES	402-20
	a. Installation	402-20
	b. Records and Maintenance	402-20

CHAPTER 402
LEVEE CONSTRUCTION AND EARTH EMBARKMENT CONSTRUCTION FOR DAMS

402-01. GENERAL

This chapter covers all operations in connection with preparing the embankment, blanket foundations and placement and compaction of all permanent fills and backfills. If a conflict should exist between this guide and the contract specifications, the contract will govern. All conflicts will be reported to your supervisor.

402-02. GENERAL PROVISIONS

a. Lines and Grades

(1) Check extent of survey work to be performed by the contractor and by the engineer.

(2) Check whether or not the engineer's survey obligations have been met.

(3) Check, prior to start of work, location of vertical and horizontal control markers established by the engineer.

(4) Check that work area limits are

plainly marked prior to start of construction operations.

(5) Check work area limits against real estate property limits to determine ownership status.

(6) Check actual conditions of the site of the proposed work for agreement with the drawings.

(7) Check contractor's layout for accuracy, control and agreement with lines and grades on contract drawings.

(8) Check that original cross sections are taken before start of construction.

b. Conduct of the Work

(1) Check protection of material, work and existing structures.

(2) Check that haul roads are approved prior to use and maintained during construction.

(3) Check rate of excavation from approved borrow sources or areas of required excavation.

(a) Is stockpiling required?

(b) Do not permit unauthorized wasting or borrowing.

c. Records

(1) Check with your supervisor prior to the start of work as to type of reports required, frequency, and data to be included.

(2) Check on reasons for reports and end use.

402-03. CLEARING AND GRUBBING

Refer to Chapter 102.

402-04. STRIPPING

a. Area Limits - Check.

b. Use of Topsoil

(1) Check stockpiling or borrowing.

(2) Check placement in work.

(3) Check wasting.

c. Stripping - Check depths.

d. Drainage Provisions - Check after stripping.

402-05. FILL MATERIALS

a. General

(1) Check sources.

(2) Check material in place for classification.

(3) Check that unsuitable materials are not placed.

(4) Check various types of fills and the locations of each.

402-06. EXCAVATION

a. General

(1) Check use of suitable materials.

(2) Check disposal of materials to be wasted.

(3) Check location of work limits.

(4) Check controls, horizontal and vertical.

(5) Check grades on "cut" stakes.

b. Specific

(1) Check line and grade of foundation excavation.

(2) Check excavated section of channels and ditches.

(3) Check removal of unsuitable material.

(4) Check fill material from borrow.

(5) Check excavation areas for drainage.

(6) Check use of interceptor ditches to control runoff.

(7) Check finished slopes as excavation progresses.

(8) Check slope tolerances as the work progresses.

c. Excavation Where Blasting is Employed

(1) Check for blasting pattern.

(2) Check use of test blasts before starting a full scale blasting program.

(3) Keep a record of quantity of powder used per blast, the number of the fuse delays used, blasting caps, and the depth and spacing of the holes.

(4) Check finished slopes in the blasting area for fractures due to over blasting.

(5) Check size of blasted rock.

(6) Check on need of changing blasting pattern.

402-07. PREPARATION OF FOUNDATION

a. Bond - Check bonding of foundation material and fill.

b. Fill - Fill depressions with material which is to be placed immediately above the foundation.

c. Loosen Foundation - Check that the area is scarified, plowed or harrowed.

d. Cleanup - Check foundation is compacted after removal of roots or other debris turned up in the process of loosening.

e. Rock Foundation Preparation

(1) Check that all loose material is removed.

(2) Checks of area to be in contact with impervious materials.

(a) Rock Surface - Thoroughly cleaned by washing and brooming.

(b) Cracks, joints and crevices cleaned out using air and/or air-water jets.

(c) Cleaned joints and cracks completely filled with portland cement mortar.

(d) Depressions or cavities satisfactorily filled with impervious material and compacted. Cavities that cannot be satisfactorily filled with earth shall be filled with lean concrete.

(e) No mortar or lean concrete applied or left on smooth rock surfaces.

402-08. PLACEMENT

a. Rolled Fill

(1) General

(a) Check embankment foundation prior to placement of fill.

(b) Check during placement that the embankment is free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding material.

(c) Check that fill is not placed on frozen material, snow or ice, and that frozen earth is not placed in the embankment.

(d) Check grade of temporary construction slopes.

(e) Check types of material:

1. Keep at same level unless otherwise specified.

2. Check mixing of materials.

(f) Check layer thickness and compaction of hand placed material.

(g) Check surface drainage of completed portions.

(2) Controlling Factors

(a) Check thickness of layers.

(b) Check material, being placed, for gradation at specific location.

(c) Check moisture content specified "after compaction".

(d) Check rate of placement.

(e) Check removal of oversize boulders.

(f) Check need for scarifying or wetting layers exclusive of the rock fill.

(g) Compaction by Rolling Equipment - Check as follows:

1. Type of roller.

2. Number of passes.

3. Number of rows when tamping rollers used in tandem. Note limitation on tandem rollers in true alignment.

4. Overlap of each pass.

5. Method used when compaction by roller impossible.

b. Hydraulic Fill for Dams

(1) General

(a) Check for segregation during placement.

(b) Check gradation of materials.

(c) Check slopes of impervious central core and pervious shells.

(d) Check rate of construction.

(2) Controlling Factors

(a) Check gradation of the material being supplied for the sluicing or pumping.

(b) Check the gradation of material in the core.

(c) Check material in the shell.

(d) Check core width.

(e) Check core is free of sand lenses.

(f) Check location of discharge lines.

(g) Check consolidation of core.

(h) Check depth of core pool.

402-09. MOISTURE CONTROL - ROLLED FILLED SECTIONS

a. General

(1) Check moisture content of materials to be placed.

(2) Check moisture content limits.

b. Impervious Sections

(1) Check for dryness.

(2) Check method of wetting:

(a) In borrow pit.

(b) On fill - Check uniform distribution.

(3) Check for too wet material in fill. Dry each layer.

(4) Check need for water meter.

(5) Check moisture content after compaction.

c. Random Sections - Check that same control is used as for impervious material or pervious material.

d. Pervious Sections

(1) Check that water is added after material has been spread on the embankment.

(2) Check method of wetting.

(3) Check that fines are not washed out when wetted.

e. Filter Drainage Layers - No moisture control required.

f. Rock Fill Sections - No moisture control required.

402-10. COMPACTION

a. General

(1) Check compaction requirements for various soils prior to start of work.

(2) Check testing.

(3) Check that compaction is obtained within moisture content limits.

b. Soil Types as Related to Compaction

(1) Check specific types - Cohesionless, Cohesive and In-Between.

(2) Check methods of compaction for various types.

c. Methods of Compaction - Compaction can be accomplished by the following methods:

(1) Surface Rolling - Check that fills are built up in thin layers.

(2) Vibration - Check use for foundation work, utilizing thin layers and cohesionless soils.

(3) Water

(a) Check this method carefully on other than controlled hydraulic fill operation.

(b) Check use as a supplement to surface rolling and vibration.

(4) Tamping

(a) Check for uniformity in results.

(b) Check for use in areas that cannot be reached by other methods.

d. Types of Compacting Equipment

(1) Tamping Sheepsfoot Roller

(a) Check for weight per linear foot of drum, weighted and empty.

(b) Check number of units.

(c) Check length and diameter of drums.

(d) Check length of projection of feet from drum.

(e) Check face area of feet.

(f) Check spacing and staggering of feet.

(g) Check device for cleaning feet.

(h) Check rolling units on multiple-type tamping rollers for use on uneven ground surfaces and independent rotation.

(i) Check speed of rolling.

(2) Rubber-tired Roller

(a) Check load per wheel.

(b) Check number of wheels.

(c) Check tires for size and operating pressures.

(d) Check position of wheels.

(e) Check spacing of wheels.

(f) Check speed of rolling.

(3) Crawler-Type Tractor

(a) Check size and weight.

(b) Check for use on cohesionless soils.

(4) Electrical Vibrators

(a) Check vibrations per minute.

(b) Check area of contact.

(c) Check thickness of layers.

(5) Air Tampers

(a) Check coverage by operator.

(b) Check for use in restricted areas.

(c) Check for thin lifts.

(6) Gasoline Driven Tamper

(a) Check use in trenches.

(b) Check coverage by operator.

(c) Check for thin lifts.

(7) Grid Roller

(a) Check for use in highway work.

(b) Check contact pressures.

(8) Segmented Roller

(a) Check for use on subbase and bases.

(b) Check size.

(9) Vibratory Roller

(a) Check weight and number of vibrations.

(b) Check for use on cohesionless soils.

(c) Check speed of rolling.

e. Moisture Density Relationship

(1) Check relationship between moisture content and dry density under a given compactive effort.

(2) Check results of laboratory data and field compaction.

(a) Check by field test section.

(b) Check by regular fill operations at start of job.

402-11. HYDRAULIC FILL FOR LEVEES

a. Hydraulic Placement - Check method against approved plan of operations.

b. Outlets

(1) Check that waste water is conducted away from embankment.

(2) Check frequency of outlets.

(3) Check that no obstruction is between end of discharge pipe and outlet.

(4) Check for transverse retaining dike.

(5) Check pollution of stream at waste water outlet.

c. Damage - Check discharge of waste water.

d. Rehandling of Hydraulic Material

(1) Check method, non-compacted or semi-compacted.

(2) Check dryness of material.

402-12. DRESSING

a. Overbuilding of Embankment - Check that sufficient material is placed to permit settlement and dressing to grade.

b. Final Grade - Check full section obtained, considering tolerances.

c. Roughness of Surface - Check that surface is free of depressions and has uniform grade.

402-13. STONE PROTECTION

a. Material - Check stone against approval for quality and size.

b. Placement

(1) Check base for compaction and grade.

(2) Check depth.

(3) Check gradation after placement.

(4) Check surface grades.

c. Gravel Surfacing

(1) Check gradation, coverage and depth.

(2) Check segregation.

402-14. ZONING OF MATERIALS IN LEVEES

a. Homogeneous Material - Check use in section.

b. Nonhomogeneous Material

(1) Check use of impervious material.

(2) Check use of most pervious in landside berms.

(3) Check whether pervious or impervious to be used in riverside berms.

(4) Check gradation of riverside impervious facing.

402-15. GRADE TOLERANCES AND SHRINKAGE ALLOWANCE FOR LEVEES

a. Tolerances - Check permissible amount in final dressing.

(1) Check grade of crown and side slopes.

(2) Check no abrupt changes or depressions.

b. Shrinkage Allowance

(1) Check shrinkage allowance for that portion constructed by the uncompacted fill method.

(2) Check shrinkage allowance for the portion constructed by the semi-compacted fill method.

402-16. SETTLEMENT OF FOUNDATION OF LEVEES

a. Installation - Check type, arrangement and spacing of these devices.

b. Records and Maintenance

(1) Check recording readings are taken.

(2) Require maintenance of devices during construction.

(3) Check payment provisions in event of failure.

CHAPTER 404
DRILLING FOR SUBSURFACE INVESTIGATIONS
INDEX

Para.	Title	Page
404-01	GENERAL	404-1
404-02	GENERAL REQUIREMENTS	404-1
	a. Type of Investigation	404-1
	b. Equipment	404-1
	c. Reports	404-1
	d. Markers	404-2
404-03	SURVEY CONTROL	404-2
	a. Location	404-2
404-04	SAMPLES	404-2
	a. Type	404-2
	b. Handling	404-3
404-05	OPERATION	404-3
	a. General	404-3
	b. Drilling and Sampling	404-4

CHAPTER 404
DRILLING FOR SUBSURFACE INVESTIGATIONS

404-01. GENERAL

This chapter covers the investigation of the distribution, type, and physical properties of subsurface materials. These investigations pertain to foundations, borrow, and ground water.

Subsurface investigations are usually accomplished by drilling, auger boring, or excavating test pits, trenches, or shafts.

404-02. GENERAL REQUIREMENTS

a. Type of Investigation - Check purpose, depth, type of materials, ground water conditions prior to start.

b. Equipment

(1) Check that equipment to be used will serve intended purpose.

(2) Study usages of various types of equipment.

c. Reports

(1) Check with supervisor as to reports required and data to be submitted.

(2) Understand reasons for report data.

d. Markers - Check for installation of permanent exploration markers.

404-03. SURVEY CONTROL

a. Location

(1) Check each exploration is located accurately by tie-in to survey grids or established base lines.

(2) Check elevations are established from existing vertical control.

(3) Check permissible variation of locations.

(a) Foundation Exploration - Minor only.

(b) Borrow Exploration - Reasonable

404-04. SAMPLES

a. Type

(1) Representative disturbed

(2) Undisturbed

b. Handling

(1) Check sample to assure it is representative of the material. Do not scalp over, undersize, or blend materials from layers or lenses.

(2) Check that undisturbed samples are protected from jarring, vibration, and exposure to heat or frost.

(a) Check method of packing.

(b) Check transportation.

(3) Check that each sample is identified.

(4) Check need for moisture content testing.

404-05. OPERATION

a. General

(1) Check that written permission has been obtained from landowner, where appropriate.

(2) Check requirements for fencing, covering, or closure of pits.

(3) Check backfilling and grading of excavation.

b. Drilling and Sampling

(1) Recheck purpose versus type of equipment.

(a) Check penetration resistance.

(b) Check soils classification.

(c) Check cleaning out of casing prior to undisturbed sampling.

(d) Check use of drilling mud in lieu of casing.

(e) Check water table.

★U.S. Government Printing Office: 1977-780-677 Region 8